COMBUSTION

DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

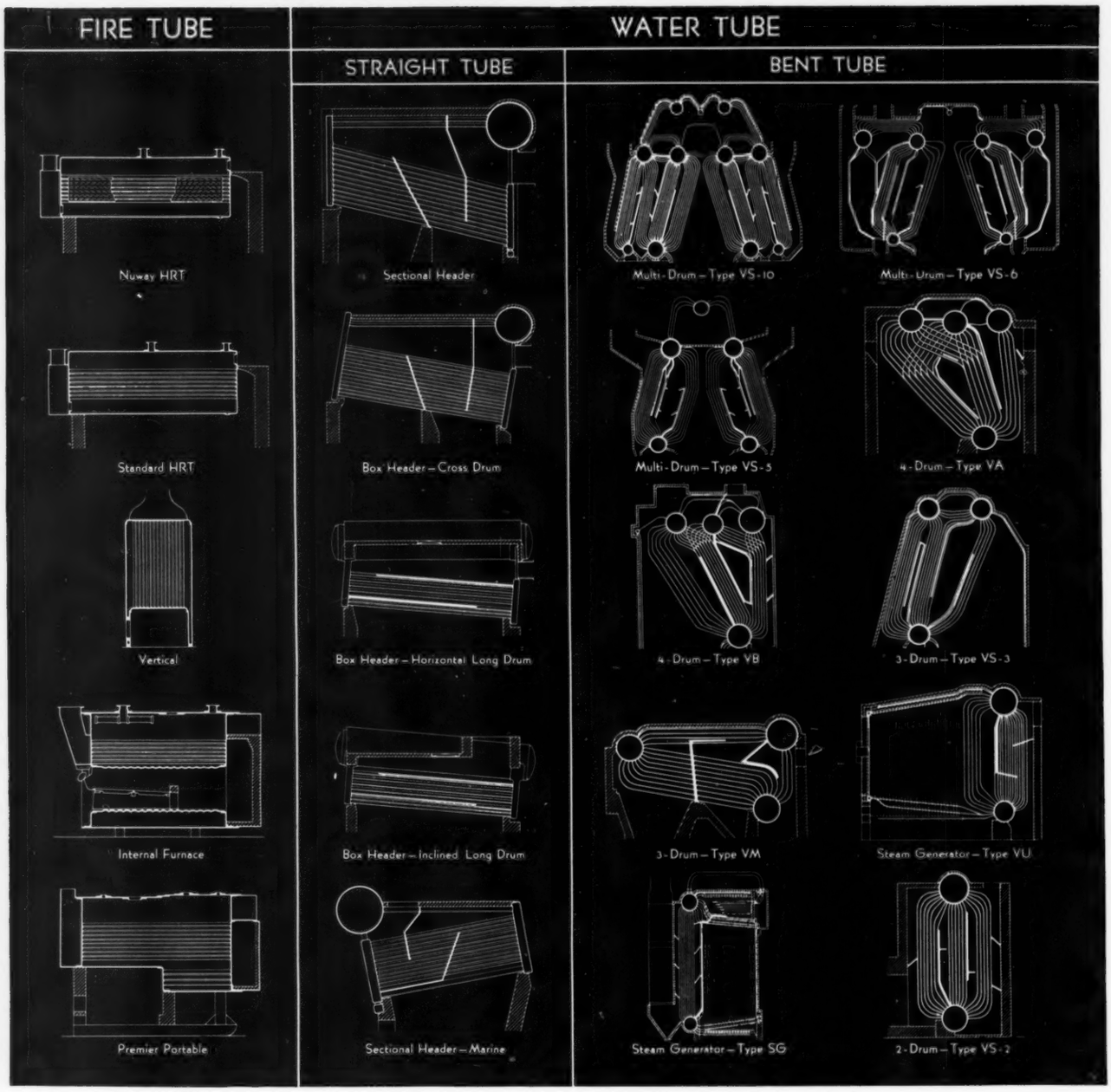
ol. 9, No. 1 | JULY, 1937 | 25c a copy

JUL 26 1937

Night view of boiler plant, City of Hastings, Nebraska

The Significance of Sulphur in Coal to the Consumer

Heat Transfer—Counterflow vs. Parallel Flow



CE PRODUCTS

All types of

BOILERS

STOKERS

FURNACES

PULVERIZED FUEL SYSTEMS

HEAT RECOVERY EQUIPMENT

•

Fabricators of pressure vessels, tanks, etc., welded or riveted in carbon, alloy or clad steels

CE BOILERS

ALL TYPES—ALL SIZES

NO matter what your steam requirements may be, there is a CE Boiler which will fit your needs precisely. Although the above sketches show the different types of boilers in the CE line, they do not include all the variations possible in arrangement of heating surfaces, baffling, etc., nor do they include special designs developed by Combustion Engineering to meet unusual conditions. • In buying a CE Boiler you assure yourself of these advantages—the right boiler for your particular requirements; advanced design features; proper coordination of boiler with furnace and related equipment; first class construction and workmanship, and competent installation. • The net result is an installation that will meet the performance specified and that will operate dependably and economically throughout its lifetime.

COMBUSTION ENGINEERING COMPANY, INC.

200 Madison Avenue, New York, N. Y. • Canadian Associates, Combustion Engineering Corporation, Ltd., Montreal

A-375

MANUFACTURING PLANTS: Hedges-Walsh-Weidner Division, Chattanooga, Tenn.; Heine Boiler Division, St. Louis, Mo.; Raymond Pulverizer Division, Chicago, Ill.; Coshocton Iron Division, Monongahela, Pa.

COMBUSTION

DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

VOLUME NINE NUMBER ONE

CONTENTS

FOR JULY 1937

FEATURE ARTICLES

Heat Transfer—Counterflow vs. Parallel Flow *by J. H. Sengstaken* 16

Smoke Prevention and Elimination of Dust from Stacks of Generating Stations *by D. C. Weeks* 21

New Steam Generating Units for Central Stations 24

Security of Employment in the Engineering Profession 27

The Significance of Sulphur in Coal to the Consumer *by Henry Kreisinger* 28

Operating Experiences with Krämer Mill Firing at the Zschornewitz Power Station *by A. Bachmair* 30

EDITORIALS

Regional TVA's Proposed 15

Hydrostatic Testing 15

DEPARTMENTS

Steam Engineering Abroad 33

New Catalogs and Bulletins 36

Equipment Sales—Boiler, Stoker and Pulverized Fuel 39

Advertisers in This Issue 40

H. STUART ACHESON, *Advertising Manager*

ALFRED D. BLAKE, *Editor*

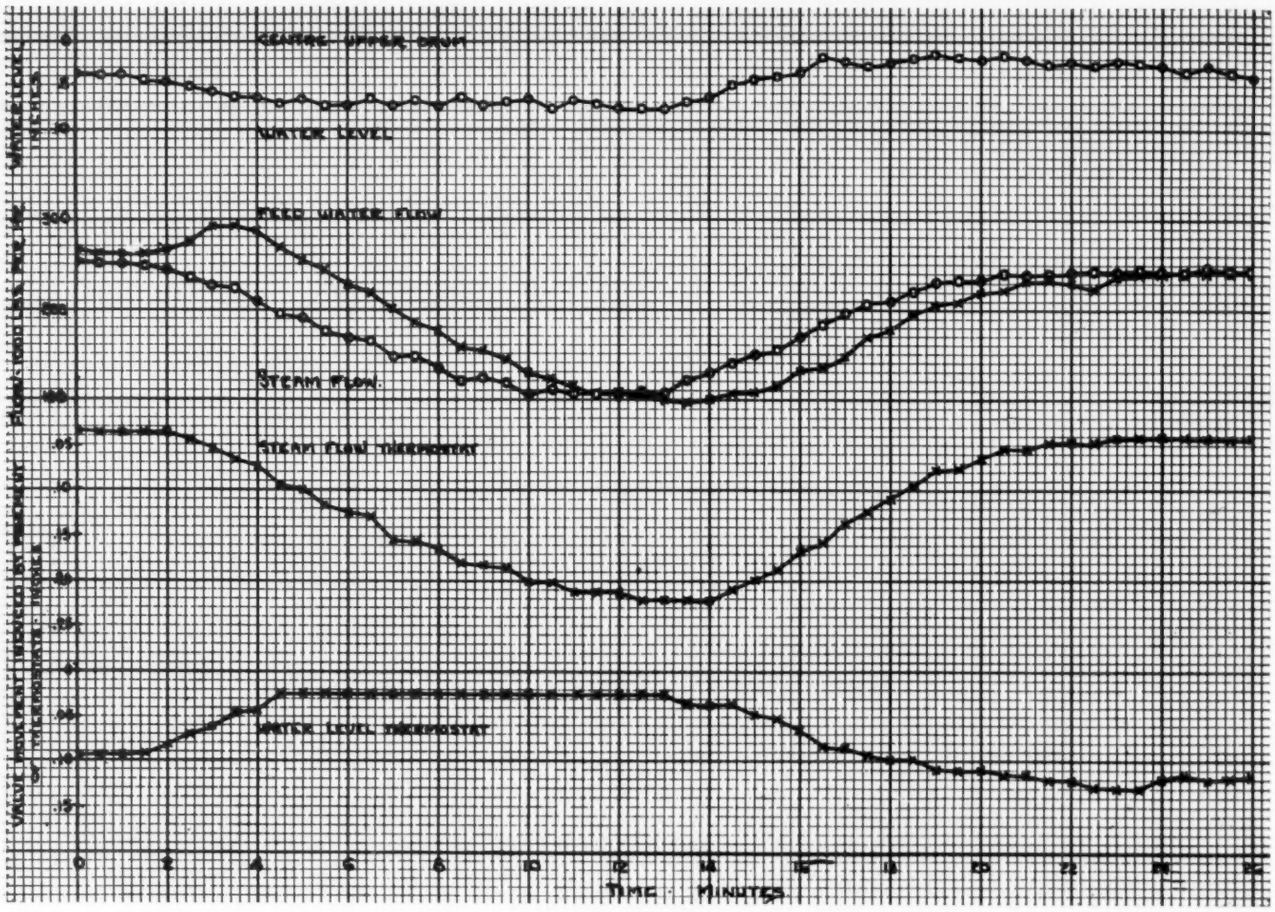
THOMAS E. HANLEY, *Circulation Manager*

Combustion is published monthly by Combustion Publishing Company, Inc., a subsidiary of Combustion Engineering Company, Inc., 200 Madison Avenue, New York. Frederick A. Schaff, President; Charles McDonough, Vice-President; H. H. Berry, Treasurer; G. W. Grove, Secretary. It is sent gratis to consulting and designing engineers and those in charge of steam plants from 500 rated boiler horsepower up. To others the subscription rate, including postage, is $2 in the United States, $2.50 in Canada and Great Britain and $3 in other countries. Single copies: 25 cents. Copyright, 1937, by Combustion Publishing Company, Inc. Printed in U. S. A. Publication office, 200 Madison Avenue, New York. Issued the middle of the month of publication.

Member, Controlled Circulation Audit, Inc.

CCA

Maurits Tests Steam-Flow Type COPES Double Control Regulator



Here is one of an interesting series of test charts on the COPES Double Control Regulator at the Government Power Station, Maurits, The Netherlands. With the prevailing rapid, wide load fluctuations, best operating results come if the boiler water level is about 8 inches higher on a load of 242,000 pounds per hour than at 88,000 pounds. The COPES Double Control, a steam-flow type regulator, gives this desired characteristic—just as it can be adjusted to give you any water level characteristic you want.

In this test, the load was dropped from 253,000 to 110,000 pounds per hour in 10 minutes, carried there for three minutes, then pushed up to 242,000 pounds in another 10 minutes. Readings were taken every 30 seconds. Note how the COPES Double Control lowered the water level as the load decreased, and raised the level as evaporation increased.

Dr. F. W. Van Berckel, who directed these tests at Maurits, discussed them in the June issue of Power Plant Engineering. May we send you a reprint of his unusual article—and discuss with you the possibility of making your boiler operation more efficient with COPES Double Control Regulators? No other steam-flow type regulator is so widely used today.

NORTHERN EQUIPMENT CO., 716 GROVE DRIVE, ERIE, PA.

FEED WATER REGULATORS - DIFFERENTIAL VALVES - PUMP GOVERNORS - CONDENSATE DRAINAGE AND LIQUID LEVEL CONTROLS - BALANCED, FLOAT, MOTOR, THRUSTOR AND PRESSURE REDUCING VALVES.

COPES
SYSTEM OF BOILER FEED CONTROL

BRANCH PLANTS IN CANADA - ENGLAND - FRANCE - GERMANY - AUSTRIA - ITALY - SALES AND SERVICE REPRESENTATIVES IN PRINCIPAL INDUSTRIAL CENTERS THROUGHOUT THE WORLD.

EDITORIAL

Regional TVA's Proposed

There are two bills now pending before Congress, one sponsored by Senator Norris and a companion measure by Representative Mansfield, both providing for the creation of seven regional planning agencies to study and report on plans to promote navigation, control floods, protect against soil erosion and provide for hydroelectric development as a part of these multiple-purpose projects, along the lines of the TVA. These bills were introduced immediately following the President's message on the subject on June 3. By those close to the situation, they are interpreted as a move toward a nationwide system of regional hydro development and power integration by the Federal Government.

The regions designated are the Atlantic Seaboard, the Great Lakes and Ohio Valley, the Tennessee and Cumberland River Basins, the Missouri and Red River Basins, the Rio Grande, Arkansas and Red Rivers, the Colorado and Southwestern Basins and the Mississippi Valley region.

It would seem that in view of our highly developed transportation systems, present navigation facilities are adequate, but the need for flood control in certain sections cannot be questioned and expenditures for such purposes would receive general approval. However, an attempt to load such expenditures with the additional cost of hydroelectric development in regions where it is not needed is sure to incur strong opposition.

As an experiment in regional development the TVA has yet to prove its case. Millions upon millions of the taxpayers' money have been poured into this project and an impartial allocation of the expenditures chargeable to power is still forthcoming. Until something definite has been learned from this experiment it is unwise to multiply it sevenfold.

From figures filed with the Federal Power Commission hydroelectric investment costs in private developments, with a few exceptions, vary from about $125 to $350 per kilowatt of installed capacity. But to be comparable with steam power at $100 or less per kilowatt of capacity, such figures must be converted into costs per kilowatt of primary capacity, which is defined as power available ninety per cent of the time. On this basis the foregoing hydro figures are increased from one and a half to ten times, depending upon the flow conditions and upstream control. This explains why so many of the less favorable sites have not been privately developed.

Although money can be borrowed by the Government at lower rates than are usually attainable in private financing, this advantage is likely to be more than offset by the higher construction costs under public procedure.

In the final analysis, the present rate of extending steam capacity throughout the country assures keeping pace with the demand in the most economical manner without further burdening the taxpayer with many hydro developments of doubtful value.

Hydrostatic Testing

A recent newspaper account of a man being killed by happening to be directly in the path of a jet of high-pressure gas suddenly released through a defect in the container, raised the question among a group of engineers as to the possible effect of a jet of water issuing from a high-pressure boiler while under hydrostatic test.

Few new boilers are absolutely tight when first tested hydrostatically, but the leaks around tube ends, handhole plates or gaskets usually develop before a considerable pressure has been built up and are in the form of seepage or minute jets that are soon dissipated. It has been pointed out that, even where a leak develops at high pressure, the capacity of the hydrostatic pump is so small that the pressure is immediately relieved before any appreciable volume of water can be discharged. Of course, the initial impingement of a jet of large diameter might be extremely unpleasant or inflict injury if a person were close and directly in its path, but where such larger jets might most likely occur are in locations where persons are not likely to be.

Viewing the problem from another angle, however, the compressibility of water, as given in the handbooks, is one part in three hundred thousand per pound of pressure exerted, so that under two thousand pounds per square inch the water would be compressed by one-one hundred and fiftieth of its original volume. This compression, disregarding the pump, would act to sustain a jet until the original conditions were reestablished.

Another point that may be raised is the fact that no containers, regardless of the thickness of the walls, are completely inelastic. The elasticity of steel is about one-twentieth of one per cent per thousand pounds pressure and the amount of expansion of a high-pressure boiler drum under two thousand pounds pressure when cold would in its effect be at least equivalent to that produced by the compressibility of the water.

Furthermore, if a considerable amount of air were entrapped within the unit its expansion would serve as a sustaining force for the jet, but care is always taken to vent the air fully as the boiler is filled and that entering with the water is in solution, hence it would exert little influence. Therefore, under the proper procedure, air may be dismissed as a factor.

Obviously, if any metal part were to let go the result might be disastrous, but the care exercised in building present high-pressure boilers and the thorough inspection to which they are subjected renders this possibility very remote.

While an analysis of the problem serves to discount such dangers as may seem apparent at first glance and, despite the absence of accidents from this cause, it nevertheless behooves those not directly concerned with such a test to exercise caution when around a high-pressure vessel that is under test, and especially one should avoid standing in front of flanges and elbows.

HEAT TRANSFER—
Counterflow vs. Parallel Flow

By J. H. SENGSTAKEN*

Combustion Engineering Company, Inc.

Many readers may be familiar with the formulas here given but plotting them in the manner employed not only simplifies their use and application but also gives a graphic representation of what heat recovery can and cannot be accomplished economically for almost any set of conditions. Figs. 5 and 6 are of particular interest in that they show the exact relation between counter- and parallel flow. The complete set of curves should be of value to all engineers dealing either with the design or operation of heat exchange equipment.

IN any heat transfer equipment the heat absorbed per hour by the cooler fluid is equal to that transferred by the heating surface, and to that given up by the hotter fluid. For convection heat transfer this may be expressed as follows, assuming no change of state in either fluid:

$$(t_2 - t_1)W_2C_2 = R \times S \times MTD = (T_1 - T_2)W_1C_1 \quad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

in which

T_1 = initial temperature of the hotter fluid, deg F
T_2 = final temperature of the hotter fluid, deg F
t_1 = initial temperature of the cooler fluid, deg F
t_2 = final temperature of the cooler fluid, deg F
W_1 = weight of hotter fluid, lb per hr
W_2 = weight of cooler fluid, lb per hr
C_1 = specific heat of the hotter fluid, Btu per lb per deg F
C_2 = specific heat of the cooler fluid, Btu per lb per deg F
R = overall rate of heat transfer, Btu per hr per sq ft of heating surface per degree mean temperature difference
S = heating surface, sq ft
MTD = logarithmic mean temperature difference, deg F

For counterflow, in which the two fluids flow through the apparatus in opposite directions, the mean temperature difference is obtained from the formula:

$$MTD = \frac{(T_1 - t_2) - (T_2 - t_1)}{\log_e\left(\frac{T_1 - t_2}{T_2 - t_1}\right)} \quad \ldots\ldots\ldots (2)$$

and for parallel flow, the mean temperature difference is:

$$MTD = \frac{(T_1 - t_1) - (T_2 - t_2)}{\log_e\left(\frac{T_1 - t_1}{T_2 - t_2}\right)} \quad \ldots\ldots\ldots (3)$$

Figs. 1 and 2 indicate diagrammatically the difference between the two types of flow. From inspection of these curves, it will be noticed that for counterflow, the

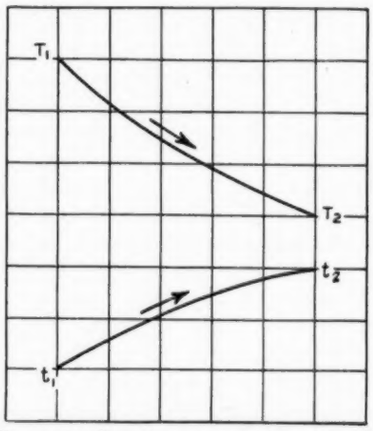


Fig. 1—Curves indicating counterflow heat transfer

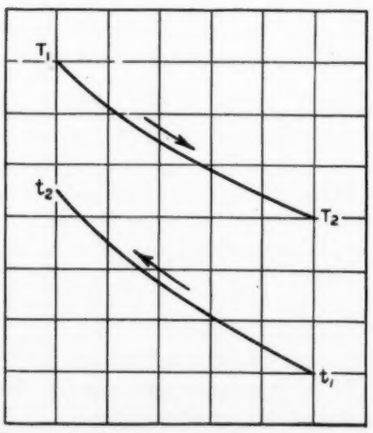


Fig. 2—Curves indicating parallel flow heat transfer

highest temperature to which the cooler fluid can be heated is the initial temperature of the hotter fluid. In contrast to this, the use of parallel flow limits the maximum temperature to which the cooler fluid can be heated to the final temperature of the hotter fluid. It is therefore obvious that much higher heat recoveries are pos-

* Chairman, A. S. M. E. Heat Transfer Committee.

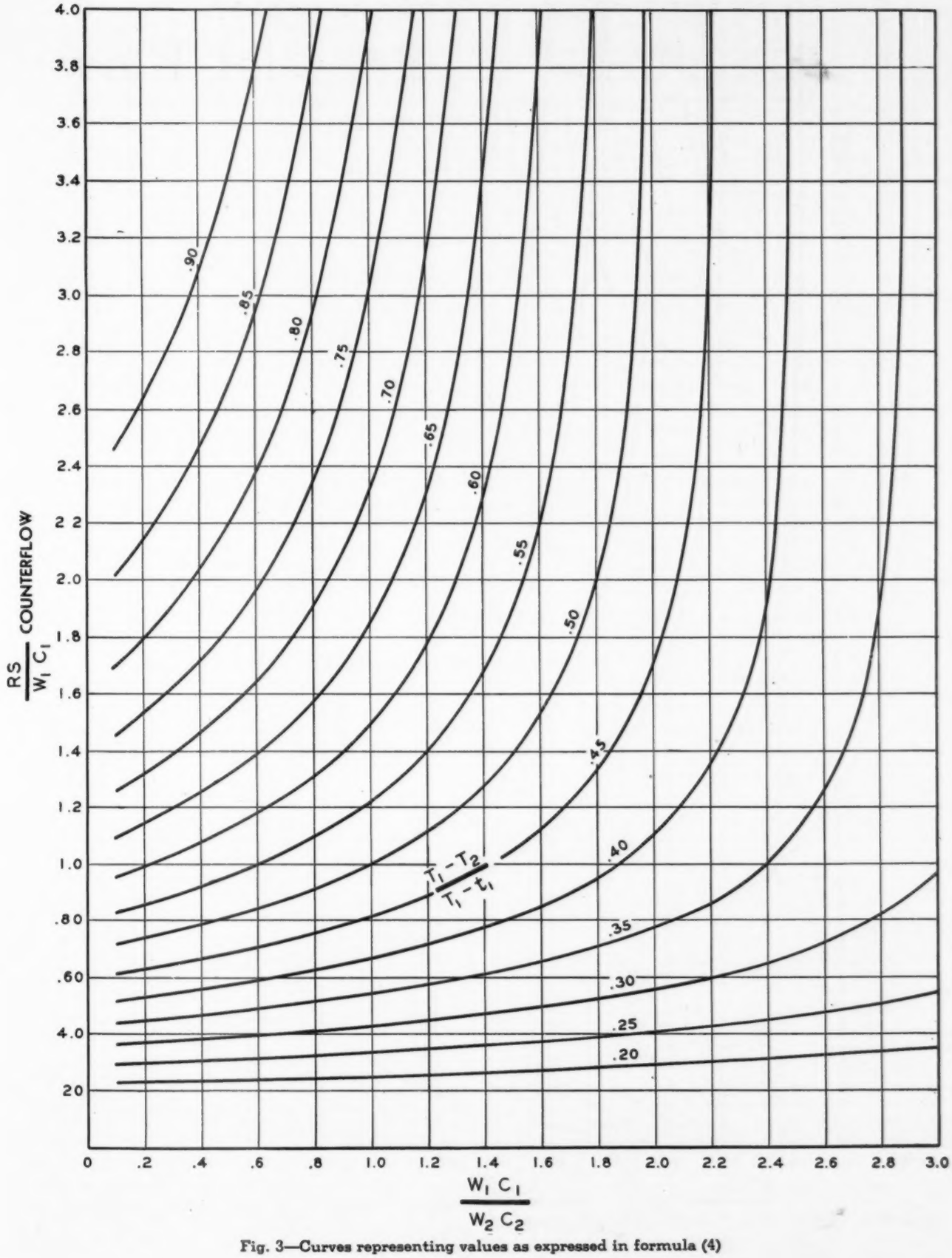


Fig. 3—Curves representing values as expressed in formula (4)

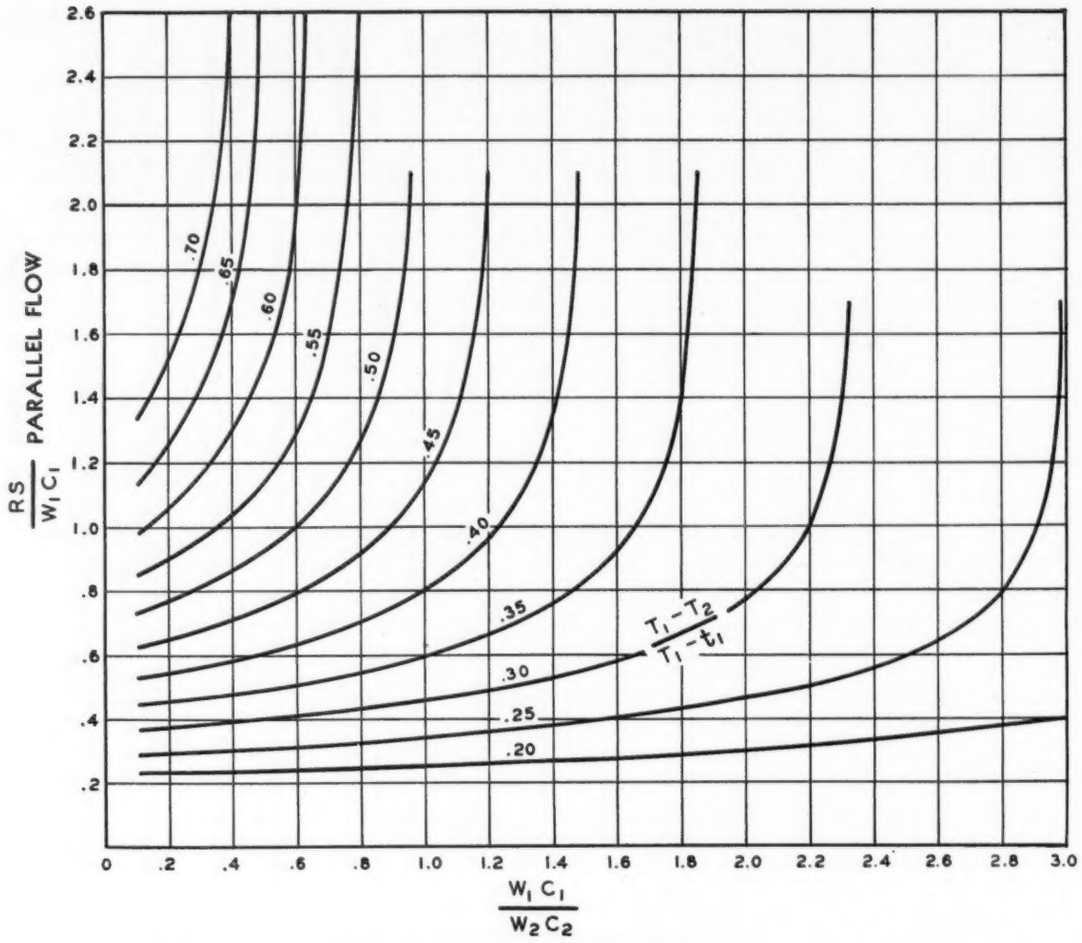


Fig. 4—Curves representing formula (5)

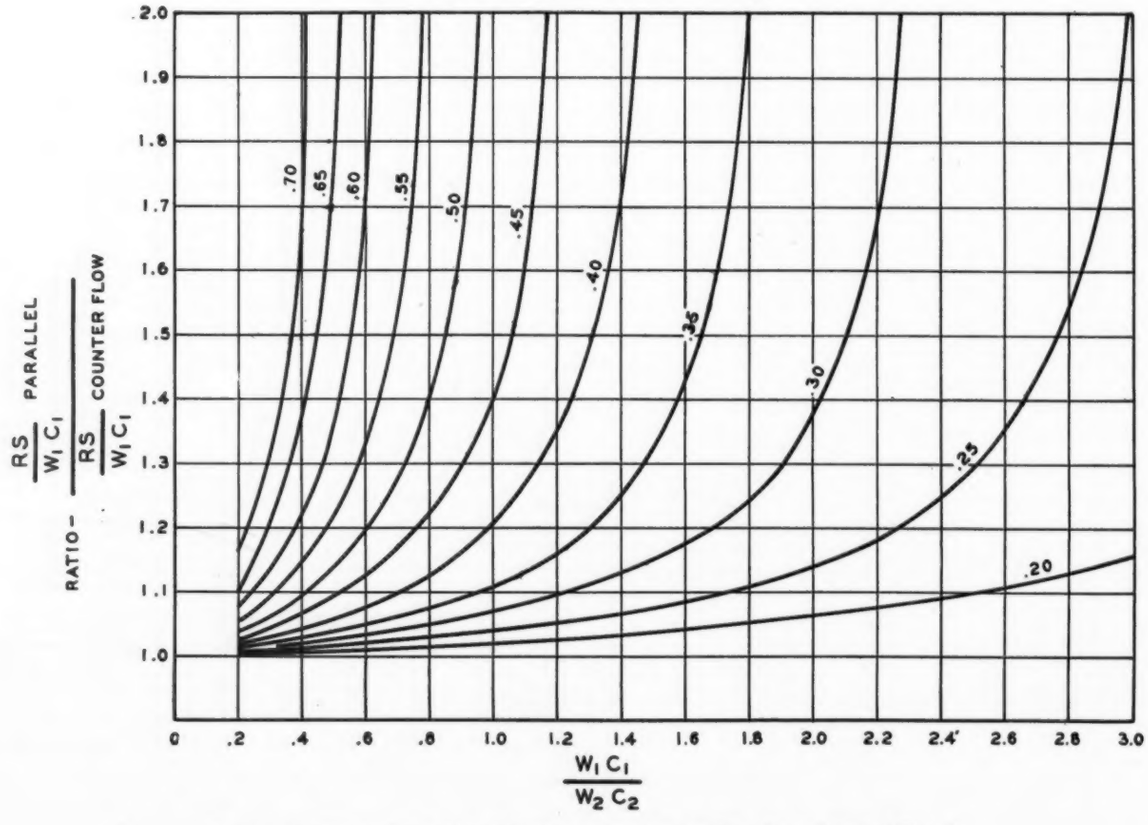


Fig. 5—Curves representing relation of values in Fig. 4 to those of Fig. 3

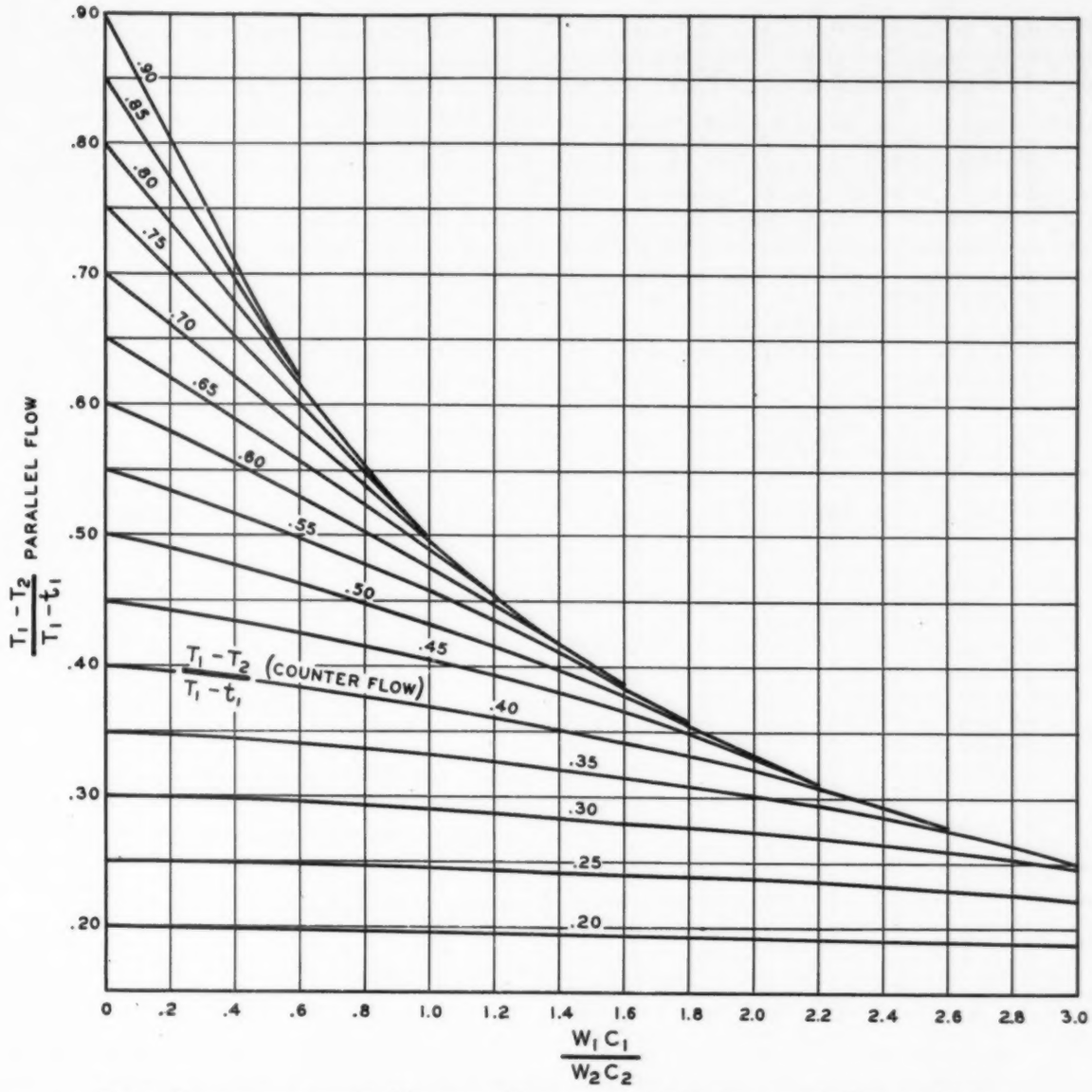


Fig. 6—Heat recovery provided by counterflow compared with that provided by parallel flow

sible when counterflow is employed. For this reason and the fact that with the heat recoveries ordinarily obtained the mean temperature difference with counterflow is much greater, the vast majority of installations of heat transfer equipment are of this type.

Referring again to Figs. 1 and 2, since T_1 is the highest and t_1 the lowest temperature available with both parallel and counterflow, the expression, $(T_1 - t_1)$, is a measure of the total heat that could be transferred to the cooler fluid by an exchanger of infinite size.

The expression

$$\frac{T_1 - T_2}{T_1 - t_1}$$

shows the relation between the actual temperature drop as provided by an exchanger of practical size and the theoretical maximum.

By transposing the second and third terms of equation (1), we have

$$\frac{RS}{W_1C_1} = \frac{T_1 - T_2}{MTD}$$

Combining this with equations (2) and (3) it can be shown that for counterflow,

$$\frac{T_1 - T_2}{T_1 - t_1} = \frac{1 - e^{-\frac{RS}{W_1C_1}\left(1 - \frac{W_1C_1}{W_2C_2}\right)}}{1 - \frac{W_1C_1}{W_2C_2}\, e^{-\frac{RS}{W_1C_1}\left(1 - \frac{W_1C_1}{W_2C_2}\right)}} \quad \ldots\ldots(4)$$

and for parallel flow,

$$\frac{T_1 - T_2}{T_1 - t_1} = \frac{1 - e^{-\frac{RS}{W_1C_1}\left(1 + \frac{W_1C_1}{W_2C_2}\right)}}{1 + \frac{W_1C_1}{W_2C_2}} \quad \ldots\ldots(5)$$

Formulas (4) and (5) are plotted in Figs. 3 and 4, respectively. Both have been calculated over ranges for both $\frac{RS}{W_1C_1}$ and $\frac{W_1C_1}{W_2C_2}$ greater than those usually encountered in actual practice, and are therefore of use in any heat transfer problems met with in the power plant or in industrial processes in which there is no change of state in either fluid.

For example, in the design of a heat exchanger, the quantities of the two fluids available, their characteristics and the rate of heat transfer are known. The curves indicate the quantity $\frac{RS}{W_1C_1}$, in which the heating surface S is the only unknown, for any heat recovery desired. For the operator, they are an accurate indication of the effect of fouled surfaces on the performance of heat exchangers, economizers, air preheaters or other kinds of heat transfer equipment.

Fig. 5 is of interest in that it indicates the relation between the heating surface required for any heat recovery with parallel flow as compared with counterflow for the same rate of heat transfer,

$$\frac{\frac{RS}{W_1C_1}\ \text{(parallel flow)}}{\frac{RS}{W_1C_1}\ \text{(counterflow)}}$$

and therefore, for equal heat exchange, shows the difference between the heating surfaces required.

Given any heat exchanger of the type to which the curves are applicable, and operating on either the parallel or counterflow principle, Fig. 6 indicates what the performance will be if the types of flow are changed from one to the other.

Applications of the Curves

There are many uses for the curves shown, particularly in the analysis of the costs and returns from the installation of one or the other type of flow. The reduction in the cost of piping to and from a heat exchanger, by changing from counter- to parallel flow may justify the increase in size for the same heat recovery, or a slight loss in heat recovery for the same initial cost. Similarly, possible reductions in flue and air duct costs, or the elimination of interferences with steel work, etc., may warrant the study of parallel flow in the application of economizers or air preheaters or both.

As stated previously, the formulas and curves apply to only those instances in which there is no change of state, and the temperature of the cooler fluid is increased as it absorbs heat. Where the fluid being heated is evaporated, as in the case of a boiler, its temperature remains constant, and t_1 and t_2 in equations (2) and (3) are equal. Formulas (4) and (5) are then reduced to:

$$\frac{T_1 - T_2}{T_1 - t} = 1 - e^{-\frac{RS}{W_1C_1}} \quad \ldots\ldots\ldots (6)$$

which applies only to convection heat transfer and does not include the heat that is absorbed in the boiler by radiation.

In any heat exchanger, involving both increasing cold fluid temperatures and evaporation, the combination of either formula (4) or (5) with number (6) may be used. In such a case, S, as used in (4) and (5) is that portion of the total heating surface of the exchanger to which these formulas apply and S in formula (6) is that heating surface at which evaporation is taking place.

Creep Testing for Turbines

Modern steam turbines operate at such high temperatures and under such high pressures that designing engineers must guard against the stretch of steel used in their construction.

In the turbine factory of the General Electric Company at Schenectady are automatic electric furnaces, held at temperatures which occur in turbines. In them, rods of turbine materials, under constant tension, are tested for years at a time. A turbine may change size as time goes on, provided such changes are symmetrical and uniform, but the changes must not exceed about one part in a thousand. The measuring gages on these furnaces easily indicate changes in rod length of one part in a million, and it is possible to watch, from week to week, the creep of these heated and stressed rods and to determine what stresses may be used without excessive distortion.

In a high-speed machine, an hourly change in length of one part in 100,000,000 is not unreasonable, and this test equipment can detect such movements in a week's time. Scientists claim that the spacing between atoms of iron measures approximately 1/100,000,000 in. Perhaps the imposed stress gradually pries an atom loose from its neighbor so it can grasp the next atom beyond. If this divorce and reattachment occurs as often as once per hour per inch of length, the material maintains its continuity and strength; but if it happens oftener than once a second, the material is unsuitable to withstand the temperatures and pressures in turbines.

Creep testing makes it possible to weed out undesirable materials and incorporate in turbines only steels which will maintain their shapes and dimensions within allowable limits during the lifetime of the turbine.

Personals

Charles W. E. Clarke has rejoined the staff of United Engineers & Constructors Inc. as consulting engineer with headquarters at 1401 Arch Street, Philadelphia, Pennsylvania.

Blake R. Van Leer, for several years dean of the College of Engineering of the University of Florida, has accepted the position of dean of engineering at North Carolina State University, Raleigh, N. C. Dean Van Leer was formerly assistant executive secretary of the American Engineering Council at Washington.

C. R. Beardsley, general superintendent of distribution construction of the Brooklyn Edison Company was recently elected to the Board of Directors of the American Institute of Electrical Engineers for a four-year term. He was past chairman of the New York Section, A.I.E.E., and has long been active in various engineering societies.

Dr. A. E. White, professor of metallurgical engineering and director of engineering research at the University of Michigan, was elected president of the American Society for Testing Materials at its Fortieth Annual Meeting in New York late in June.

J. W. Scott of Indiana has been named by President Roosevelt as a member of the Federal Power Commission, succeeding H. J. Drane whose term expired on June 22.

Smoke Prevention and Elimination of Dust from Stacks of Generating Stations*

By D. C. WEEKS

Consolidated Edison Company of New York, Inc.

Considering the production of smoke as an index of reduced efficiency, the author reviews the operating procedure and the process of coal selection employed by his company to keep the emission of smoke to a minimum. The steps taken to avoid objectionable discharge of fly ash and cinders are described and the effect of stack diameter on the apparent density of smoke is discussed.

SMOKE abatement for those of us who either literally or figuratively work under the stacks of large power plants absorbs a very substantial portion of our thoughts and energies. Not that dense smoke is made any time but smoke, no matter how little it may be, is an index of imperfect combustion and imperfect combustion is an index of reduced efficiency. Even a small reduction in efficiency when applied to more than four million tons of coal a year, which is the amount of coal burned by the steam plants of the Consolidated Edison System, would amount to a preventable loss of real magnitude and one which would justify the expenditure of considerable time and money to overcome.

Selection of coal for the particular boilers in which it is to be used is an item of first magnitude in obtaining efficient combustion and one which has been given a great deal of attention in all of our power plants. The usual laboratory analysis, although it has a very definite place in controlling the uniformity of coal shipments, does not give an accurate picture of the burning characteristics of the coal in the furnaces, and burning tests of several days duration and at the highest firm rating which is expected of the boilers are made on several test cargoes before any considerable tonnage of that particular grade of coal is purchased. These tests are carefully observed by a number of men for smoke, coking characteristics, condition of the fuel bed, fly coke, slag and clinker. The flue gas is also analyzed and every effort is made to determine whether the coal is suitable in every detail. This process of coal selection and the checks which are regularly made on each cargo have resulted in each boiler receiving a high grade fuel best suited for its particular characteristics. This is true of the stoker-fired and pulverized-fuel-fired boilers, alike.

In practice perfect combustion of coal depends on supplying more than a sufficient quantity of air together with the necessary time, temperature and turbulence to complete the reaction before the products of combustion strike the comparatively cool boiler tubes. Looking in some detail at stoker-fired boilers burning a well selected grade of semi-bituminous coal, it is obvious that the first step for ideal combustion lies with the fuel bed. The coal which enters the stoker in the retorts must, in the process of coking, spread well out over the tuyères and the air from the tuyères permeate and percolate through the coal in the retorts if uniform combustion is to take place over the entire fuel bed area. Furthermore, the coal must move down the stoker at comparatively slow and uniform rates to prevent the rapid breaking up of any particular section of the fuel bed with the consequent release of an excessive volume of volatile matter. The formation of clinker is not consistent with good combustion because it upsets both a steady flow of coal and air and their uniform admixture. After leaving the fuel bed, and this is particularly true in larger furnaces, the gases require a high setting in order to permit time for the final reactions to take place. It has been customary practice to determine with the Orsat the air-fuel ratio required and to set the boiler meters accordingly. However, the Orsat does not give an accurate index of perfect combustion and a more complete analysis of the flue gas is required. A larger air-fuel ratio than is indicated by the Orsat is necessary to obtain complete combustion in the furnace.

Improvements in Stoker Design and Operation

Over a period of years, very definite improvements have been made in the design and operation of our stoker-fired boilers. In the matter of design high furnace settings are no longer an innovation but have been the rule for a number of years on all of our newer installations. Over 90 per cent of the power generated by the Consolidated Edison System in 1936 was generated by steam produced in modern high setting boilers. The older boilers with low setting are carried at low ratings to prevent any possibility of imperfect combustion. With regard to the stokers themselves many changes have been made, in the type of tuyère, the type and depth of retorts, the stoker slope and the type and length of stroke of secondary rams, all for the purpose of improving the admixture of air and coal in order to perfect combustion in the furnace and to reduce to a minimum any blasting action with its consequent formation of cinders. Recognizing that some cinder still forms despite the improvements instituted, our boilers are all equipped with efficient cinder catchers. In addition, our largest stoker-fired boilers have their windboxes sectionalized into 69 zones so that if any section of the fuel bed becomes particularly thin the air in that section

* A paper presented at the 31st Annual Convention of the Smoke Prevention Association, New York, June 4, 1937.

may be reduced in order to prevent an increased cinder loss and to give the stoker the opportunity to correct the thin spot without the interference of high air velocity at the weak point.

Overfire Air Employed

In order to prevent the possibility of smoke at the higher ratings when the time for combustion is reduced and increased turbulence is required, a number of boilers at some of our stations are equipped with overfire air. The use of auxiliary air gives additional turbulence to gases in the furnace and additional air for the combustion of these gases. The installation in those boilers equipped with auxiliary air consists of a large number of comparatively small ports placed a short distance above the fuel bed at the head of the furnace. These ports are connected by ducts to either the main air ducts or to separate fans. This process has proved to be quite successful in perfecting combustion in some cases but not entirely so in others. Tests are in progress at the present time to further develop the process so that it will be more effective in all cases.

Handling Rapid Increases in Load

The electric load in New York City varies widely over the period of a day. During the evening the load is usually at its peak, at which time it is approximately four times that existing during the early morning hours. For this reason it is necessary to have a large number of boilers under steam to carry the evening load. These are not necessary during the early morning hours, hence they must be banked during this period. Were any one group of boilers banked over the entire low load period, the fuel beds would become decidedly ragged and the boiler settings comparatively cool so that when the boilers were brought up in the morning to pick up the increasing load there would be a tendency to produce smoke. The pickup in load between 7 a.m. and 9 a.m is very rapid, often increasing 100,000 kw in a few minutes. It is particularly important, therefore that the fuel beds have a large reserve of incandescent fuel to take care of these rapid increases in load and to do so without the formation of smoke. This is accomplished by rotating the banked boilers during the early morning hours so that no boiler is banked for more than a very short period. The fuel beds are also well built up ahead of time so that the green fuel which is added may be added slowly and become coked and incandescent in readiness for the load pickup which can then be handled easily with very little possibility of smoke formation or reduced efficiency. The boilers are all equipped with automatic control so that during the peak period the steaming boilers all come up together automatically. In this way no one boiler or small group of boilers can be pushed up above a furnace rating at which it can operate safely without danger of smoke formation. Due to the characteristic of our boiler efficiency curves, all of which have a drooping characteristic from banked rating up to maximum rating, there is no incentive to limit the number of boilers on the line and to carry high boiler ratings over the peak, as it is more economical and more efficient to carry sufficient steaming boilers so that the peak load may be carried by boilers operating at reasonable ratings, and at such ratings there is very little possibility of the formation of smoke.

Reduction of Fly Ash from Pulverized-Coal-Fired Boilers

A number of years ago the Consolidated Edison System started experimenting with pulverized fuel with the thought to effect more perfect combustion than was then possible with stokers. The results of these experiments and those of other plants all over the country were felt to justify the installation of pulverized fuel boilers. As far as combustion is concerned the problems which were many at the start have been well taken care of and the intimate mixture of fuel and air, together with time, temperature and turbulence which are possible make these boilers particularly efficient over a wide range of steaming rates. The air separation used in the mills has very effectively minimized the possibility of admitting coarse particles of fuel to the burners. During recent years the energies of all concerned have been concentrated in the reduction of fly ash. This has been attacked both in the furnace and at the stack. As each new installation goes into service fly ash is continually reduced. Larger and larger percentages of the ash slag to the furnace bottom and are tapped off as molten slag or collect on the slag screens or boiler tubes where it can be blown down from the surfaces from time to time. The fly ash which escapes from the boiler and travels on toward the stack is very effectively trapped before reaching the stacks. Several of the boilers are equipped with Cottrell precipitators, others with spray-type cinder catchers, and still others with cyclones.

The satisfactory measurement of the density of smoke leaving the stacks of power plants, factories, apartment houses, office buildings, tug-boats, steamers, etc., is a problem that has given all of us interested in smoke abatement a great deal of concern. The rather crude Ringelmann chart method is still in vogue not because it is satisfactory but rather because no better method has been devised and generally accepted. Smoke recorders and indicators are being widely tried out and we have quite a number of such devices on trial in our various power plants. However, they have not been thoroughly proven and we depend on the observations of our smoke inspectors, who watch the stacks of our generating stations, for any possible increase in the stack emission which usually appears as a light gray haze.

Stack Cross-Section Affects Ringelmann Reading

In this connection it should be pointed out that the Ringelmann method makes no allowance for the thickness of the column of smoke and therefore does not give a fair comparison of the density of smoke emission between large and small stacks. For instance, if the Hudson Avenue Station in Brooklyn were equipped with one hundred stacks instead of four with exactly the same emission from the boilers a smoke inspector would observe each of these one hundred stacks as approximately $^1/_2$ Ringlemann when he would observe one of our present stacks as No. 3 Ringelmann. A number of smoke tests have been made to prove this. It can be done by fixing a rectangular outlet to a small stack making a very heavy smoke from the furnace underneath and observing the smoke first from the short and then from the long axis of the outlet fixture. It can also be done by placing a large smoke box on top of a furnace and fitting the smoke box with several sizes of stacks.

Of course, certain objections might be raised to this latter method as to the uniformity of the density of the smoke in the smoke box although it was equipped with a stirrer to insure the uniformity of the smoke, and secondly, objection might be raised as to the difference in resistance and chimney action of these four stacks although very careful corrections were made for these. The differences in the appearances of the smoke streams in the different sizes of stacks were very marked, either when using transmitted light or reflected light and also when using a number of different backgrounds to simulate the varying conditions of the sky.

There is nothing new about this phenomenon. It has been known and used in various types of scientific work for many years. It has been recognized by the state of Massachusetts with regard to smoke and it is our feeling that allowance for stack size should be recognized in other sections as well. That the situation regarding smoke and smoke violations is recognized in some quarters in the Metropolitan area of New York is well brought out by an editorial which appeared in the *New York Herald Tribune* of January 1, 1937 entitled, "The Problem of Smoke." It reads as follows:

> "No one would belittle the new process devised by chemists at the University of Illinois to scrub smoke discharged into the air, but dreams of smokeless cities based on this discovery are not quite so imminent as every one would like to believe. What the process does is to remove the sulphur gases from smoke by washing with a solution that absorbs them, and if need be saves them. It naturally is applicable only to relatively large factories or power plants. Even for these, the reduction of sulphur gases will not be matched by equal reduction in soot. Any reduction at all in pollution of the air is to be welcomed, but the Illinois process, even should its sponsors' fondest hopes be realized, ought not to divert attention from the real problem of city smoke, which is something quite different.
>
> "The real problem is that of small, numerous and widespread fires. Paradoxical as it may seem to laymen, the greatest single cause of the notable smoke reduction in New York City since 1929 has been the growth of large power houses and steam plants, replacing many private ones. A second has been the substantial decrease in smoke from the railway yards in New Jersey. A third was the depression, but more because of unoccupied apartments and offices than because of idle factories. A certain quantity of coal must be burned somewhere each year to keep New York warm, lighted and in motion. The part of this coal burned in small private fires makes much more smoke per ton than that burned in large plants, where smokelessness is dictated by economy as well as by the law. This concentration of soot reduction in large plants will be even more true of any reduction of sulphur by the new process from Illinois.
>
> "Much misunderstanding of the smoke problem begins with an optical illusion. The thick smoke column from a large chimney looks dark. A thin stream of exactly the same smoke may be quite invisible, merely because one looks through a shorter section of it. Competent smoke surveys always reach the conclusion that this so-called invisible smoke from small chimneys contributes at least a half and often more than four-fifths of all the soot particles in any city's air. Inspection of this invisible smoke obviously is impossible, nor has much public favor been attracted to compulsory use by every one of expensive smokeless fuels. Both sulphur and soot will keep coming from all our thousands of small fires so long as these exist. The best thing is to discourage them, to encourage further use of electricity, gas and public-service steam."

Liability of Employers

By LEO T. PARKER

Attorney at Law

Various courts have held that an employee is bound to obey the order of his employer unless the command includes a violation of the law, or the act required is *so obviously dangerous* that no employee of ordinary prudence would undertake to perform it. Where the employer himself gives the order and the employee obeys it, and is injured as a consequence thereof, of course, the employer is liable. If the order is given by a representative or agent of the employer who occupies toward him the position of vice principal, the same result follows. However, a mere employee cannot become a vice principal by an usurpation of authority.

Another rule of the law is that if another employee is injured by conduct of a fellow servant when he speaks for the employer, the employer is liable.

Also, it is important to know that the higher courts have consistently held that if an employee in obedience to a command of the employer, or at the command or request of another employee having either express or implied authority to make such command or request performs an act within the scope of the employer's business, which would not but for the command lie strictly within the scope of the employee's particular employment, he will still by reason of his obedience to the command be deemed to be acting within the line of his duty and employment since the command given by the employer or by another employee having authority to give such command will serve to enlarge the scope of the employment to include the act done in obedience thereto.

It is well known that no employer, either under the Workmen's Compensation Laws, or in a damage suit filed by an employee, is liable for an injury sustained by an employee who acts "outside the scope of the employment."

Therefore, it is interesting to know that an injury is received "in the course of the employment" when it comes while the workman is doing the duty which he is employed to perform. It "arises out of employment" when there is apparent to the rational mind, upon consideration of all the circumstances, a causal connection between the conditions under which the work is required to be performed and the resulting injury. Under this test, if the injury can be seen to have followed as a natural incident of the work, and to have been contemplated by a reasonable person familiar with the whole situation as a result of the exposure of danger occasioned by the nature of the employment, then it "arises out of the employment."

NEW STEAM GENERATING UNITS for Central Stations

A list of central station boiler units recently placed in service or now under construction showing the trend in types of units, steam conditions, methods of firing, types of furnaces and heat recovery equipment employed. Only units of more than 100,000 lb per hr capacity are included and the tabulation does not include municipal plants. While the number of high-pressure superposed installations continues to grow, many plants are putting in steam generating units for pressures of 750 to 900 lb.

AT a joint meeting of the A. S. M. E. and the World Power Conference delegates last September at Niagara Falls, Professor A. G. Christie presented a very excellent paper on American power plant practice in which he gave a table containing boiler data on about thirty of the later installations, both central station and industrial. These data were assembled in July 1936. Since then construction in the central station field has been very active. Superposition of high-pressure boilers and turbines has been extended to many of the older stations and a number of new stations have been projected. Therefore, in order to bring the reader up to date as to what has been going on in the way of central station steam generating practice, the accompanying table has been prepared of boiler installations now under construction or recently completed.

The table does not cover all the high-pressure installations inasmuch as those that have been in operation for more than a year, or were projected prior to the present construction era, have been omitted with a view to depicting current trends only. A few other installations have been omitted because, for various reasons, data were not at present available. No attempt has been made to include a considerable number of smaller units under 100,000 lb per hr capacity. Neither municipal plants nor industrial plants have been considered, although some of the latter have boiler installations under way comparable both in capacity and steam conditions with central station practice.

The list has been arranged in three groups, namely, high-pressure, intermediate-pressure and lower-pressure installations. All of those in the high-pressure group and some in the intermediate-pressure group are superposed units. In the latter, however, are also to be found several new stations, three of which are to employ steam generating units of 400,000 lb per hr capacity at 840 lb pressure and 900 F steam temperature. Moreover, these are laid out with one boiler per turbine. This unit system also applies to a number of the superposed installations although in these, two boilers per turbine, especially for the larger units, is more common. Among the new stations are three of the semi-outdoor type.

Perusal of the table shows that for those stations where load conditions warrant, the trend toward large units continues; also the employment of high steam temperatures. A few units of large capacity and relatively low steam pressure are being installed but these represent extensions of certain stations under the existing steam conditions where superposition was not warranted.

Pulverized Coal Firing Predominates

Of the 109 steam generating units listed pulverized coal is employed in 68, stokers in 20 and oil or gas in 21. With the exception of one station, namely, Conners Creek, all of the units of more than 350,000 lb per hr capacity are fired with pulverized coal or oil. The employment of dry-bottom furnaces will be found to exceed slightly those of the slagging type, but this has little significance as to a trend inasmuch as load conditions and the ash-fusion temperature of the coal burned are usually important factors in dictating the choice of furnace bottom.

Among the high-pressure units, while the five largest are of multi-drum bent-tube design, this type breaks about even with the straight-tube sectional-header type for the group and special designs account for seven. In the intermediate-pressure group, however, there are 53 units of the multi-drum bent-tube type, 6 of the sectional-header straight-tube type and 11 of the radiant, integral-furnace and the "VU" types. Grouped according to capacity, there are 43 units of the multi-drum bent-tube type, 19 of the straight-tube sectional-header type and 7 of the radiant type among units of 250,000 lb per hr and over.

The low-pressure group includes all the foregoing types with none predominating, although in this pressure range, in capacities up to 220,000 lb per hr, will be found a considerable number of the two-drum designs such as the C-E "VU" type and the B & W integral-furnace type.

In a few cases the types of heat recovery equipment have not yet been definitely fixed and in some others such information was lacking. Enough have been included, however, to show that in most of the high- and intermediate-pressure installations both economizers and air heaters are being employed. In practically all one form of heat recovery is used.

Partial List of Central Station Boiler Installations Now under Construction or Recently Placed in Service

List Does Not Include Units under 100,000 Lb per Hr, Municipal Plants or Boilers Built for Export

HIGH-PRESSURE INSTALLATIONS

Station	Company	No. Units	Capacity Lb per Hr	Make	Type	Design Press.	Steam Temp.	Type of Firing	Furnace Bottom	Air Heaters	Econo-mizers	Super-position	Remarks
Logan, Logan, W. Va.	Appalachian Pr. Co.	1	1,000,000	C.E.	B.T.	1325	925	P.C.	Dry	Ljungstrom	Yes	Yes	Supplies one 50,000-kw turbine
Windsor	Ohio Pr. Co.	1	750,000	C.E.	B.T.	1475	925	P.C.	Slagging	Ljungstrom	Yes	Yes	Aux. burners for superheat control; split furnace; radiant and convection superheaters.
		1	750,000	F.W.	B.T.	1475	925	P.C.	Dry		Yes	Yes	The two units will supply a 60,000-kw turbine
Schuylkill	Phila. Elec. Co.	2	660,000	C.E.	B.T.	1475	925	P.C.	Slagging	Ljungstrom	Yes	Yes	Supply one 50,000-kw turbine
Essex, Newark, N. J.	Pub. Serv. El. & Gas Co.	2	605,000	B&W	Radiant	1475	950	P.C. or Oil	Slagging	Tubular	Yes	Yes	Supply one 50,000-kw turbine
Springdale	West Penn Pr. Co., Pittsburgh, Pa.	3	500,000	B&W	S.T.	1450	935	P.C.	Slagging	Tubular	Yes	Yes	Supply one 50,000-kw turbine
Waterside	Consolidated Ed. Co., New York	4	500,000	C.E.	S.T.	1400	900	P.C.	Slagging	Ljungstrom	Yes	Yes	Each two units supply a 50,000-kw turbine
Manchester Street	Narragansett El. Co.	1	450,000	C.E.	B.T.	1350	905	P.C.	Dry	Ljungstrom	Yes	Yes	
Fisk Street, Chicago	Commonwealth Ed. Co.	2	412,500	B&W	S.T.	1450	910	P.C.	Slagging	Tubular	Yes	Yes	Supply one 30,000-kw turbine
Des Moines	Iowa Pr. & Lt. Co.	1	410,200	C.E.	B.T.	1475	925	P.C.	Dry	Ljungstrom	Yes		
L Street, Boston	Boston Ed. Co.	2	375,000	C.E.	B.T.	1400	910	P.C.	Dry	Ljungstrom	Yes	Yes	
Miller's Ford, Dayton, O.	Dayton Pr. & Lt. Co.	2	375,000	B&W	S.T.	1350	900	P.C.	Dry	Tubular	Yes	Yes	Supply one 25,000-kw turbine
West End, Cincinnati	Union G. & E. Co.	3	350,000	B&W	Radiant	1450	925	P.C.	Slagging	Tubular	Yes	Yes	Supply one 35,000-kw turbine
Rivesville, Fairmont, W. Va.	Monongahela West Penn Pub. Serv. Co.	2	315,000	B&W	S.T.	1425	915	P.C.	Slagging	Tubular	Yes	Yes	Supply one 25,000-kw turbine
Northeast, Kansas City	Kansas City Pr. & Lt.	1	300,000	C.E.	S.T.	1400	815	P.C.	Slagging	Ljungstrom	Yes	Yes	
West Reading	Metropolitan Ed. Co., Reading, Pa.	2	275,000	C.E.	B.T.	1400	900	P.C.	Dry	Ljungstrom	Yes	Yes	
Omaha	Nebraska Pr. Co.	1	275,000	C.E.	B.T.	1400	815	Stoker		Ljungstrom	Yes	Yes	Supplies one 12,500-kw turbine
Walnut Street, Groveport, O.	Columbus Ry., Pr. & Lt. Co.	2	200,000	B&W	Radiant	1475	910	P.C.	Slagging		Yes	Yes	

INTERMEDIATE-PRESSURE INSTALLATIONS

Williamsburgh, Brooklyn, N. Y.	Williamsburgh Pr. Plant Corp. (BMT)	2	575,000	B&W	S.T.	925	830	P.C.	Slagging	Yes	Yes	Yes	
12th Street, Richmond, Va.	Virginia El. Pr. Co.	1	450,000	C.E.	B.T.	925	835	P.C.	Slagging	Ljungstrom	Yes	Yes	Supplies a 12,500-kw back-pressure turbine
South Meadow, Hartford, Conn.	Hartford El. Lt. Co.	1	425,000	B&W	S.T.	950	915	Oil or P.C.	Dry	Yes	Yes	Yes	
Conners Creek	Detroit Ed. Co.	5	420,000	C.E.	B.T.	710	850	Stoker		Plate	Yes		Six similar units in the rebuilt station are now installed
New Castle	Penn Pr. Co.	1	400,000	F.W.	B.T.	840	900	P.C.	Dry	Tubular	Yes	No	New station; one boiler supplies a 35,000-kw turbine
Weadock Bay City, Mich.	Consumers Pr. Co.	2	400,000	F.W.	B.T.	840	900	P.C.	Dry	Tubular	Yes	No	New station; two boilers supply two 35,000-kw turbines
Morrow, Kalamazoo, Mich.	Consumers Pr. Co.	1	400,000	F.W.	B.T.	840	900	P.C.	Dry	Tubular	Yes	No	New station; one 35,000-kw turbine
Market Street, New Orleans	New Orleans Pub. Serv.	1	385,000	B&W	B.T.	925	905	Oil and Gas				Yes	
Elm Street, Battle Creek, Mich.	Consumers Pr. Co.	1	360,000	B&W	S.T.	900	875	P.C.	Dry	Yes	Yes	Yes	Supplies one 10,000-kw turbine
Kentucky Ave., Indianapolis	Indianapolis Pr. & Lt. Co.	2	350,000	F.W.	B.T.	680	785	P.C.	Dry	Yes	None	Yes	Supply one 12,500-kw turbine
Delray, Detroit	Detroit Ed. Co.		344,000	B&W	B.T.	950	910	Stoker		Yes	Yes	Yes	

(*Continued on page 26*)

INTERMEDIATE-PRESSURE INSTALLATIONS, *Continued*

Station	Company	No. Units	Capacity Lb per Hr	Make	Type	Design Press.	Steam Temp.	Type of Firing	Furnace Bottom	Air Heaters	Econo-mizers	Super-position	Remarks
Neches, Beaumont, Texas	Gulf States Util. Co.	1	320,000	C.E.	B.T.	950	915	Oil and Gas		Ljungstrom	Yes	Yes	
Cumberland	Potomac Ed. Co.	1	312,000	C.E.	B.T.	925	830	P.C.	Dry	Ljungstrom	Yes	Yes	
Riverside, Davenport, Ia.	United Pr. Mfg. Co.	1	300,000	C.E.	B.T.	900	825	P.C.	Slagging	Ljungstrom	Yes		
Columbia	Cincinnati G. & E. Co.	2	300,000	B&W	S.T.	775	910	P.C.	Slagging	Yes	Yes		
E. Peoria	Cent. Ill. Lt. Co.	1	300,000	Riley	B.T.	810	875	P.C.	Dry	Yes	Yes		Supplies one 25,000-kw turbine
Riverbend	Duke Pr. Co.	2	275,000	C.E.	B.T.	725	825	P.C.	Dry	Ljungstrom	None		
Acme	Toledo Ed. Co.	1	253,000	B&W	B.T.	900	825	P.C.	Slagging	Yes			
Station No. 3, Rochester, N. Y.	Rochester G. & E. Co.	3	250,000	C.E.	B.T.	750	775	P.C.	Dry	Steam	Yes	Yes	
Wells Street	Milwaukee El. Ry. & Lt. Co.	1	250,000	C.E.	B.T.	750	825	P.C.	Dry	Plate	None	Yes	
Evansville	So. Ind. G. & E. Co.	1	225,000	F.W.	B.T.	900	900	P.C.	Dry	Tubular	Yes	Yes	Supplies one 20,000-kw turbine
Mad River, Springfield, O.	Ohio Ed. Co.	1	225,000	C.E.	B.T.	900	900	P.C.	Dry	Yes	Yes	Yes	Supplies one 20,000-kw turbine
Blount Street, Madison, Wis.	Madison G. & E. Co.	1	200,000	B&W	Radiant	975	825	P.C.	Slaggin				
Seward	Penn El. Co.	2	200,000	B&W	B.T.	725	825	Stoker			Yes		
Mountain Creek	Dallas Pr. & Lt.	2	200,000	B&W	Int. Fur.	750	830	Gas and Oil					
Wichita	Kansas G. & E. Co.	2	160,000	C.E.	VU	725	835	Gas and Oil		Ljungstrom	None		New Station, semi-outdoor
W. Jackson Street, Tampa, Fla.	Tampa El. Co.	2	140,000	B&W	Int. Fur.	900	840	Oil					
Montville	Connecticut Pr. Co	2	130,000	C.E.	B.T.	900	825	P.C. or Oil	Dry	Ljungstrom	None	No	Supply a 25,000-kw condensing turbine
Jeffersonville	Missouri Pr. & Lt. Co.	1	115,000	C.E.	B.T.	900	825	P.C. Oil or Gas	Dry	Ljungstrom	None	Yes	
Manchester, N. H.	Pub. Serv. Co. of New Hampshire	2	110,000	B&W	Int. Fur.	650	760	Oil					
Dresden	N. Y. State El. & Gas Co.	2	110,000	F.W.	B.T.	725	825	P.C.	Dry	Tubular	Yes		Supplies one 20,000-kw turbine
W. Jackson Street, Tampa, Fla.	Tampa Elec. Co.	2	140,000	B&W	Int. Fur.	900	830	Oil					

LOWER-PRESSURE INSTALLATIONS

Reed, Pittsburgh	Duquesne Lt. Co.	2	350,000	B&W	B.T.	425	760	Stoker					
Minneapolis	Northern States Pr. Co.	2	275,000	F.W.	B.T.	450	750	Stoker			Yes		
Valmont	Pub. Serv. of Colorado	1	225,000	B&W	B.T.	425	750	P.C.	Slagging	Yes			
Station C, Oakland, Cal.	Pacific G. & E. Co.	2	220,000	B&W	Int. Fur.	475	725	Oil and Gas					
Broad Street, Lynn, Mass.	Lynn G. & E. Co.	1	208,000	Riley	B.T.	450	775	P.C.	Dry	Ljungstrom	None		
Provo	Utah Pr. Co.	1	200,000	C.E.	B.T.	460	760	Stoker					Supplies one 18,750-kw turbine, semi-outdoor
Omaha	Nebraska Pr. Co.	2	200,000	C.E.	VU	525	760	Oil and Gas		Ljungstrom	None		New Station, semi-outdoor
Station B, San Diego, Calif.	San Diego Cons. G. & E. Co.	2	200,000	B&W	Int. Fur.	275	740	Oil and Gas					
Cahokia, St. Louis	Union El. Lt. & Pr. Co.	5	190,000	B&W	S.T.	375	740	P.C.	Dry				Supplies one 75,000-kw turbine
Little Rock	Arkansas Pr. & Lt. Co.	1	188,000	B&W	Int. Fur.	300	617	Oil					
Evansville	So. Ind. G. & E. Co.	1	140,000	C.E.	S.T.	475	700	Stoker		None	None		
Dresser	Pub. Serv. of Ind.	1	180,000	B&W	S.T.	400	725	Stoker					
		2	100,000	C.E.	B.T.	450	775	Stoker	Tubular	None			

ABBREVIATIONS:
B.T.—Bent Tube.
S.T.—Straight Tube.
Int. Fur.—Integral Furnace.

VU—2-drum C.E. Steam Generator.
P.C.—Pulverized Coal.
C.E.—Combustion Engineering Company, Inc.

B&W—Babcock & Wilcox Company.
F.W.—Foster Wheeler Corporation.

Security of Employment in the Engineering Profession

Digest of a report issued by the U. S. Department of Labor, based on a survey covering over thirty-five thousand engineers, in which were investigated the means used to secure employment, contract and civil service protection, patent privileges and pension protection. Previous reports based on the same survey have covered educational qualifications, unemployment and employment in the engineering profession.

IT will be recalled that the U. S. Bureau of Labor Statistics about two and a half years ago initiated a survey of the engineering profession through questionnaires mailed to over fifty thousand engineers in various branches of the field. Over thirty-five thousand of these were returned filled out with the desired information, and the data thus obtained has formed the substance of four reports the last of which, as prepared by Andrew Fraser, Jr., appeared in the Bureau's *Labor Review* for May 1937. It has since been made available in pamphlet form. This report covers the means employed to secure employment, economic security as affected by contracts and by provisions for retirement on pension, and patent privileges within the profession.

Means of Obtaining Employment

The returns indicated that 68.4 per cent of the professional engineers used personal contacts and recommendations to obtain their positions. Over seventy-five per cent of the chemical, electrical and metallurgical engineers, and seventy per cent of the mechanical and industrial engineers employed this means but, as would be expected, the civil engineers secured more positions through civil service agencies; in fact, over eighty per cent of the engineers thus classified were civil engineers.

Only 2.4 per cent of all the engineers reported that they have obtained their positions through engineering societies. Despite the fact that such a small percentage reported engineering societies as their employment medium, it will be recognized that such societies are, nevertheless, an important factor in obtaining employment for professional engineers, for it is obvious that through their members there is inevitably a pooling of information on employment prospects. This results in personal contacts and recommendations which outnumber the contacts made directly through the societies' employment services.

The securing of employment through newspapers and technical journals was reported as 1.6 and 1 per cent, respectively. In this connection it is noted that, relatively, electrical, mechanical and industrial engineers found more positions through newspapers than did any of the other professional groups, whereas technical journals were of more assistance as a medium of employment to chemical and ceramic engineers. Private employment agencies were used by only 1.6 per cent of all the engineers reporting.

Although over eleven thousand of the 35,559 engineers reporting were in public service in December 1934, only 45 per cent had a civil service status. Four-fifths of these were civil engineers.

Written Contracts Relatively Few

For the engineering profession as a whole there was distinct evidence of a lack of economic security in terms of a written contract which would secure employment over a substantial period of time. In all, only 8.9 per cent of those reporting were covered by written contract. Of these, 0.8 per cent stated that they had a contract for less than a year, 3.5 per cent a contract for one to two years and only 0.9 per cent for two years or more; the remainder failed to report the period of contract. The existence of contracts was most common in personal service, particularly in educational work. For the separate fields of private engineering the largest proportion of contracts was found in manufacturing, with construction and extractive industries next and the public utilities and transportation fields lowest. The teachers formed by far (33.8 per cent of those reporting) the largest group under contract, with sales engineers, management, consulting, design and research, construction and operating engineers following in the order named.

Pension Privileges

An analysis of the data furnished showed that nearly one-third of the engineers had pension privileges. Of these the smallest relative proportion, 26.2 per cent, were engaged in private engineering. By contrast, 37.4 per cent of the engineers engaged in public work and 29 per cent of those in personal service had pension privileges. In these the contributory arrangements predominated.

Patent Privileges

Of all the engineers covered, slightly less than a third reported the retention of patent rights for all inventions made either in the course of their work or in fields not directly related to their work. Among the nine separate fields of employment this was true of the largest group in each case, except in manufacturing where the highest proportion reported that they had no rights to patents relating to their work, but did retain their rights to patents not directly related to their work. This partial restriction was very much less for the remaining fields of activity in private engineering.

In the field of public employment such restrictions were greatest in Federal service where over 12 per cent had no patent privileges whatsoever, and about the same percentage were under partial restriction.

Relative to all other fields the least restrictions were found in personal service where over half reported unrestricted patent rights, this being due largely to the preponderance of teachers in this group.

The Significance of Sulphur in Coal to the Consumer*

By HENRY KREISINGER

Combustion Engineering Company, Inc.

The form in which sulphur occurs in coal is mainly as pyrites, although small amounts may occur as sulphates or as organic sulphur. In general, it lowers the softening temperature of the ash and thereby increases clinkering and slagging troubles. Furthermore, the products of oxidation or decomposition of the sulphur compounds are highly corrosive to economizers, air heaters, flues and stacks under certain loading conditions—all of which increases both maintenance costs and operating difficulties. High sulphur coals are often difficult to store because of the increased hazard of spontaneous combustion in coal piles and bunkers. Hence the conclusion is reached that the use of such coals is justified only after a thorough trial in the individual installation in order to determine whether difficulties encountered will more than offset the lower price.

SULPHUR is an undesirable element in coal, and the consumer looks with much suspicion on coals high in sulphur. He feels that high sulphur coal is likely to give him trouble from clinkers on grates, slagging of furnaces, slagging and fouling of heat absorbing surfaces, corrosion, and pollution of the atmosphere by obnoxious gases. High sulphur coal is also likely to give trouble from spontaneous combustion in the coal storage pile and coal bunker. Even when the price of high sulphur coal is substantially lower than that of low sulphur coal, the experienced consumer will not contract for high sulphur coal without first giving it a thorough trial to convince himself that the difficulties encountered will not more than offset the advantage of the lower price.

Sulphur in coals occurs mainly as sulphide of iron, commonly known as pyrites, and as organic sulphur. A small amount of it also occurs as sulphates. Some of the troubles mentioned are caused directly by the sulphur, others are due to the iron with which a large part of the sulphur is combined.

In a boiler furnace the sulphide of iron generally burns to iron oxide and SO_2 or SO_3. In a reducing or a partly reducing atmosphere all of the iron and sulphur may not be completely oxidized and some ferrous sulphide, low oxides of iron or even metallic iron may be formed. The organic sulphur also burns to SO_2 or SO_3. The sulphates decompose at the high furnace temperature into metallic oxides and SO_2 or SO_3. The SO_2 and SO_3 are gases and pass with the gaseous products of combustion to the stack. The metal oxides and the partly burned sulphur compounds become part of the ash and are removed with it.

Clinkering and Slagging

The formation of clinker in the fuel bed of hand- and stoker-fired furnaces, slagging of furnace walls, and slagging and fouling of heat absorbing surfaces in steam generating units are the most serious troubles the coal consumer fears with high sulphur coal. Such troubles cause much additional work in the boiler plant, and increase the maintenance of the equipment; they also seriously reduce steaming capacity.

The sulphur and the iron, with which the sulphur is combined, are apt to lower the softening temperature of the ash and thereby cause clinker in the fuel bed, slagging of the furnaces, and slagging and fouling of heating surfaces. The accompanying chart is intended to show to what extent the sulphur content in Pennsylvania coals affects the softening temperature of ash. It has been prepared from Bulletin 209 of the Bureau of Mines, entitled "Fusibility of Ash from Coals of the United States," by W. A. Selvig and A. C. Fieldner, and shows that coals with ash of high softening temperature generally have low sulphur content, but not all low sulphur coals have high fusion temperature ash. However, most high sulphur coals have low softening temperature ash. Although no definite relation between sulphur content in coal and softening temperature of ash can be deduced, the chart justifies the suspicion of the coal consumer that high sulphur coal is likely to cause clinker and slag troubles. Therefore, the consumer is opposed to contract for high sulphur coals without first giving the coal a thorough trial to find if such coal can be used economically in his boiler plant.

When the coal is burned on grates either in hand- or stoker-fired furnaces, the clinker troubles are usually less serious if pyrites occur in large lumps or disks than when they are uniformly distributed through the coal. The large lumps are mostly separated from the coal and, because they are much heavier than the coal, during the process of combustion they sink to the grate out of the zone of high temperature and may not reach the softening point. There is also less sulphur and iron carried by the gases into the boiler and, therefore, there is less likelihood of slagging the heating surfaces of the boiler. This is probably the reason why some high sulphur coals may give satisfactory results as far as clinker and slagging of boiler are concerned. When such coals are burned in pulverized form most of the pyrites are pulverized and they

* A paper presented before the A.S.T.M. at New York, June 29, 1937.

are uniformly distributed through the coal and may cause slagging of the furnaces and of the boiler.

Clinkering in the fuel bed, slagging of furnaces and of the heating surfaces increase the work of operating the boilers. The clinkers and slag must be removed often from the furnaces by hand tools. Slagging and fouling of the heating surfaces require frequent operation of soot blowers and the use of hand lances. The capacity of the steam generating equipment under such operation is usually reduced because the clinker and slag and their removal hinder the combustion of fuel. The clinker and slag damage the grate and the furnace. Thus, the maintenance of the equipment is increased. Among the first questions that high sulphur coal brings to the consumer's mind are those of increased operating and maintenance costs and that of reduced capacity of his steam generating equipment.

Corrosion

The products of oxidation or decomposition of the sulphur compounds in coal are corrosive, and may cause rapid deterioration of all metallic parts with which these products come in contact. The corrosion may start in the coal-handling equipment and coal bunker where the oxidation of sulphur in the presence of moisture and air produces sulphuric acid which attacks iron or concrete. The sulphur which remains in the clinker and ash eventually reaches the ash hopper where the refuse is usually quenched. The water used in quenching picks up some of the sulphur compounds from the refuse and forms dilute acids which corrode the iron parts of the ash hopper and ash-handling apparatus. The gaseous products of combustion and decomposition of the sulphur are carried through the boiler setting with other gaseous products of combustion. When their temperature is reduced in the presence of water vapor they form acids which corrode and foul the economizer, the air heater, flue ducts and steel stacks. Water vapor is produced by moisture and the hydrogen in coal, the quenching of refuse in the ash hopper and the operation of soot blowers to remove the fouling from the surfaces. The removal of fouling with compressed air reduces the amount of water vapor in gases and thereby the acid formation, but the use of compressed air requires additional equipment for compressing the air and power for its operation. Generally, the higher the proportion of water vapor in the products of combustion the more serious is the corrosion trouble.

Low temperature of the products of combustion that favors the condensation of water vapor and the formation of acids is obtained when the boiler is started or shut down, and when it is banked. It may also be produced by feeding the economizer with water at too low a temperature. Low temperature generally occurs in air heaters at the point where the air enters the heater. Condensation of water vapor in the presence of SO_3 starts at a temperature higher than the dewpoint corresponding to the partial pressure of the water vapor.

In this connection it may be stated that fouling and corrosion of economizers and air heaters is usually more serious with high sulphur fuel oil than it is with high sulphur coal. The explanation probably is that fuel oil contains a greater percentage of hydrogen and more water vapor is formed by the combustion of oil. The sulphur in oil occurs mostly as organic sulphur and the greater part of it may burn to SO_3.

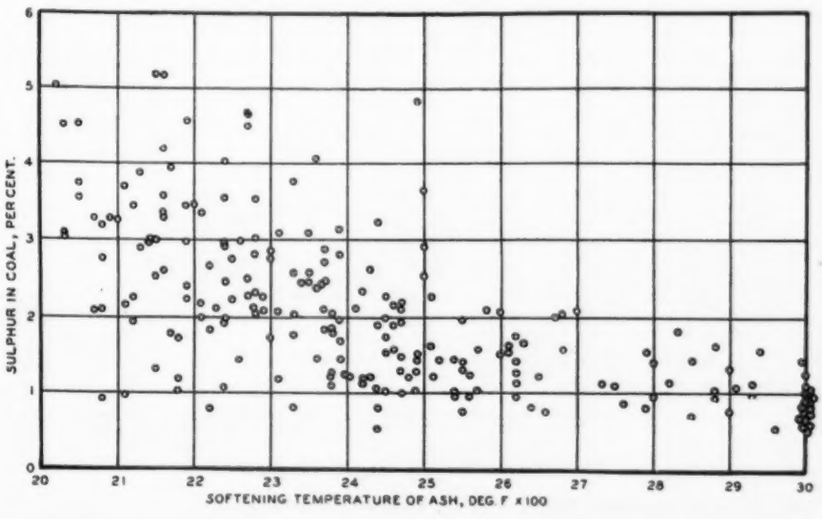
Air Pollution

The products of combustion and decomposition of the sulphur compounds passing out of the stack give the waste gases an obnoxious odor, thereby causing objectionable pollution of the air. Breathing such polluted air is very unpleasant and irritating even to healthy people, and if the plant is located near or in a town, there may be serious complaints against such air pollution.

Also, the sulphur gases are destructive to stone and concrete buildings and to paint, as well as to plant life. In the London district in England power plants are required by law to remove the sulphur compounds from stack gases before discharging to the atmosphere. In the United States the subject of air pollution by sulphur gases is kept alive by discussions at all smoke abatement and pure air meetings. While no laws have so far been proposed for compulsory removal of sulphur compounds from stack gases, much work has been done to develop an inexpensive method for such removal. The problem of air pollution by sulphur gases may be of considerable importance, requiring serious consideration by the coal consumer whose plant is located where it might cause complaints.

Storage of Coal

High sulphur coal does not store well. Slow oxidation of the sulphur lowers the heat value of the coal and increases the danger of spontaneous combustion. Even if the coal is stored in large coal bunkers for immediate use, high sulphur coal may cause troublesome fires before it is used. If a coal consumer has to store part of his coal requirements in a pile to guard against coal shortage, he is very likely to avoid high sulphur coal.



Relation between percentage of sulphur in coal and softening temperature of the ash in Pennsylvania coals.

Operating Experiences with Krämer Mill Firing at the Zschornewitz Power Station*

By A. BACHMAIR

This station, built in 1935, contains ten 132,000-lb per hr steam generating units fired by the Krämer system of burning coarsely ground coal partly in suspension and partly on grates. An account is given of the mill wear, the experience with streamline hammers, the operating procedure when carrying light loads with very wet coal, and how certain minor difficulties were overcome. Test performance of the units is also given.

THE Zschornewitz Station contains ten 132,000-lb per hr steam generating units installed in 1935 and all equipped with the Krämer mill system of firing. Of these, six are of type *A*, Fig. 1, and four are of type *B*, shown in Fig. 2. These units, the details of which are given in the accompanying table, have operated from the beginning without serious difficulties, such outages as have occurred being due mainly to the necessity of changing hammers in the mills, but these interruptions have been of short duration.

As will be noted by reference to the illustrations, grates are provided for burning out the coarse fuel. The ashes discharged from these grates contain combustible matter up to 7 per cent in the case of type *A* boilers and the flue dust taken from the breechings averages about 1 per cent combustible. In the *B* type of boiler the combustible in the ash and flue dust is somewhat lower due to higher air preheat and to finer grinding which causes less fuel to be burned on the grate.

In the beginning there was considerable slagging of the furnaces, particularly upon the hopper walls above the grates, but this has been reduced to a small amount by passing cold air through the grates. About 20 per cent of the air for combustion is now admitted through the grate in type *A* boilers and 6 per cent in type *B*, but this

* Translated from a paper in *Archiv für Wärmewirtschaft und Dampfkesselwesen*, June 1937.

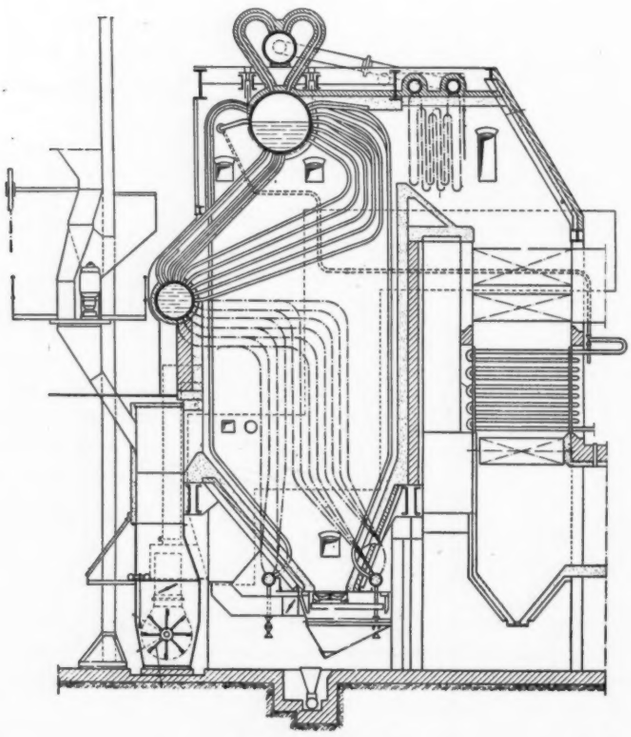


Fig. 1—Type A

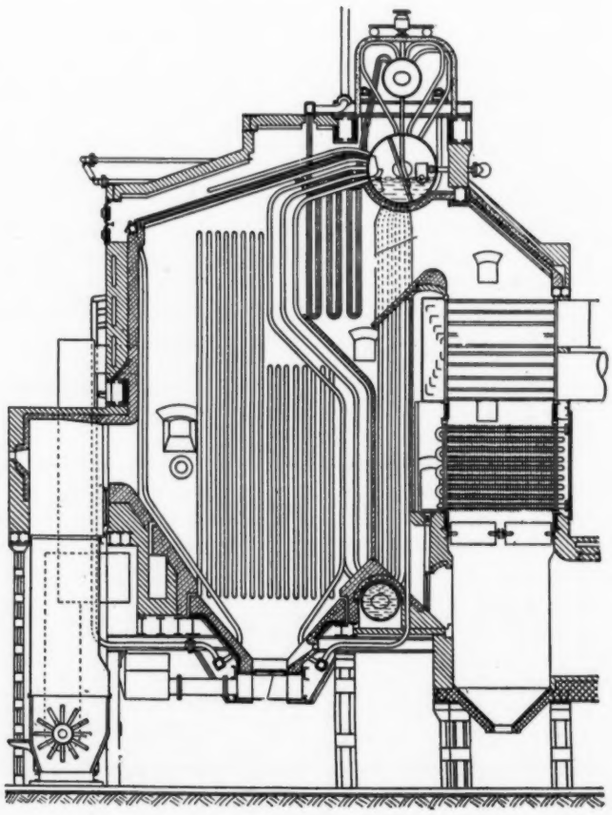


Fig. 2—Type B

Two-drum bent-tube boilers with Krämer mill firing at Zschornewitz Station

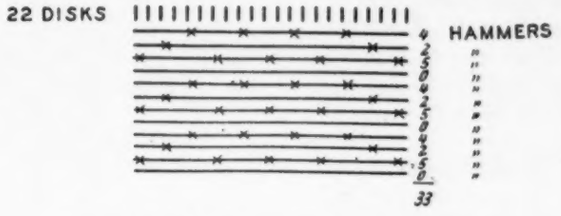


Fig. 3—First hammer arrangement type B

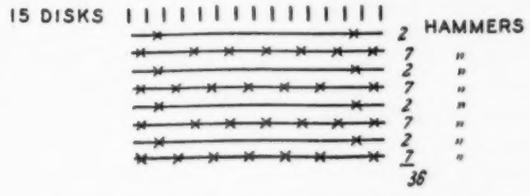


Fig. 4—Hammer arrangement with type A

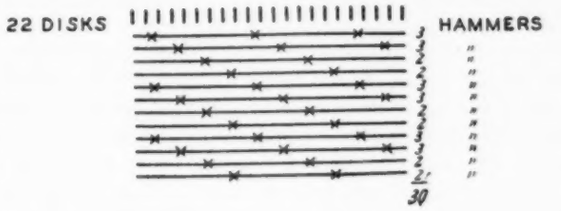


Fig. 5—Final arrangement of hammers

is employed only for loads exceeding 50 per cent of rated capacity.

The type of firing employed possesses the flexibility of pulverized coal and has the added advantages of lower power requirements and much simpler and less expensive apparatus for fuel preparation. The coal must not be ground too finely, however, and the grate must be capable of completely burning those particles of fuel which because of their size will not burn in suspension. In other words, there must be coordination between the fineness of grinding and the corresponding power demand and, above all, between the wear on the mills and the efficiency of the unit.

Mill Wear

In the beginning mill wear was the subject of much discussion and experimentation. The mills of type *B* boiler originally had 22 rotor disks with 33 hammers, spaced as shown by the crosses in the diagram of Fig. 3. Those serving the type *A* boilers had 15 disks and 36 hammers as also shown by the crosses in Fig. 4. Excessive wear appeared on the side arms of the type *B* mill and three additional hammers were added to each side, making a total of 39. The wear was thereby reduced but the additional hammers offered a higher resistance to the air blown into the sides so that full rating on the boiler could not be obtained. To correct this difficulty three hammers were removed from the middle of the mill and the side hammers moved inward by one disk. Full boiler rating was again attained but the wear on the side hammers reappeared. A reasonable hammer life was finally obtained by reducing the number of hammers to thirty and arranging them as illustrated in Fig. 5. That is, the distance between the outer hammers and the mill wall was reduced.

Fig. 6 shows the types of hammers used on mills *A* and *B*, the former being of manganese steel and the latter of high strength carbon steel, but, although the life of the hammers of the two types varied considerably, the difference in wear could not be traced to the materials used in their construction. For a certain coal of low ash and sand content the hammers of type *A* lasted for about 2400 hr whereas those of type *B* lasted only 1200 hr. Type *B* also required considerably more time for changing. The greater life of the hammers of type *A* was due principally to coarser grinding than in the case of type *B*.

In the early period of operation it was thought desirable to recirculate flue gas through the mills when operating at low loads because of the moisture content of coal, and to improve the suction of the mills for handling this recirculated flue gas, the air admission parts of type *A* mills were enlarged to an annular opening about the shaft. This change was found to effect a material reduction in the wear of the hammers; in fact, it more than doubled their life.

In this type of mill coarseness of grinding, within certain limits, is no disadvantage since the coal which is not burned in suspension is consumed on the grate. Coarser grinding is dependent largely upon the lesser distance from the mill shaft to the mill discharge opening. This distance is 20.8 ft in the case of mill *B* and 17 ft for type *A*. The form of opening also exerts some influence, that for type *B* having four openings each 4.11 ft high and 2.46 ft wide while those for type *A* were 3.6 ft high and 2.6 ft wide.

Experiences with Streamlined Hammers

The power consumption with the regular hammers amounted to 3.18 kwhr per ton of coal at the maximum output of 132,000 lb of steam per hour and 6.8 kwhr per ton at half load. To reduce the low load power consumption of the mill streamline hammers, as shown in Fig. 7, were tried. In type *B* mill such hammers made of cast steel lasted 696 hr after which the wear became so great as to require shutting down the boiler. While the idling power consumption was only about half that of the former hammers, the grinding power consumption was nearly equal. The explanation is to be found in the fact that while the streamlining reduced the windage loss,

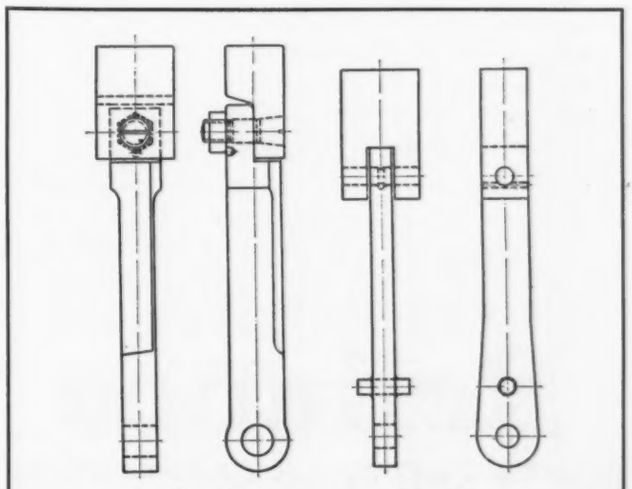


Fig. 6—Types of hammer employed

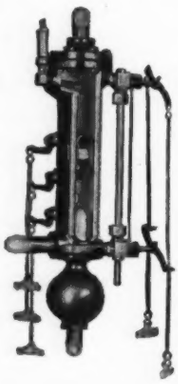
HUNDREDS OF THOUSANDS OF LIVES

HUNDREDS OF MILLIONS IN PROPERTY

DEPEND SAFELY ON THIS FLOAT

The Reliance Boiler Alarm Float, made of fused stainless metal, guaranteed unsinkable. More than twice as strong as necessary, it is highly buoyant, reacting instantly to every small fluctuation of the boiler water level, nearly 4 times as quickly as any other type of alarm.

The speedy sureness of the float operated safety water column has always made it the preferred design among power plant designers, boiler manufacturers and power engineers. When boiler pressures began to rise, Reliance chose the harder but better way, beginning a float development that has resulted in the present Reliance Float, which has performed so well over a period of years, all the way up to 850 pounds pressure, that we guarantee it unsinkable in service.



It's good business to protect your boilers with Reliance Alarms

Reliance

TRADE MARK REG. IN U.S. PAT. OFF.

BOILER SAFETY HEADQUARTERS

THE RELIANCE GAUGE COLUMN CO.

5902 Carnegie Ave. Cleveland, Ohio

the grindability was reduced by the diminished impact area, so that the coal had to be reduced within the mill sump by the hammer.

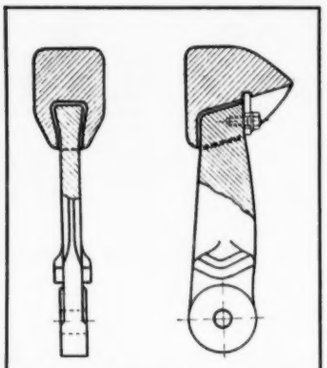


Fig. 7—Streamline hammer

The Krämer mill firing has proven especially adapted to burning wet brown coal. Tests were made to determine how low a boiler load could be carried without encountering difficulties. These were made on one of the type *A* boilers, employing recirculated flue gas in the mill and it was found possible to operate satisfactorily at an output of 28,600 lb per hr or about one-fifth rated capacity. However, since the boiler was normally operated with fresh air to the grates and warm air to the mills, a change in damper settings was required each time to introduce flue gas at low boiler ratings and this likewise involved resetting the dampers in the air line to the mills. This worked a hardship on the operating crew and a trial was therefore made without flue gas recirculation at low loads. This disclosed that it was possible to maintain low boiler loads under the usual operating conditions. Type *B* boiler maintained a load of 22,050 to 33,000 lb per hr while type *A* maintained 44,100 lb per hr as a minimum load. Since lower loads were not required during normal operation of the plant the practice of recirculating flue gas was discontinued.

Very wet coal was found to arch in the bunkers and thus interrupt the coal feed. This difficulty was overcome by means of air jets operating under 100 lb per sq in. pressure, the jets of air issuing from flat nozzles located within the bunker at such points as to break down the arching. In both types of units coal was fed by a drag chain which proved to be weak in construction. This link breakage was partly due to an unequal pull on the 85 ft chain. A flexible design of chain was substituted and overcame this difficulty.

Starting Up the Boilers

The practice in starting up the boilers at this station is to build a wood fire on the grate and shortly thereafter start the coal feed. This has been found most satisfactory. The oil burners originally supplied and the addition of dried coal was found unnecessary. With ignition from the wood fire it is possible to attain a steaming capacity of 66,000 lb per hr, or half the maximum rating in about 40 min.

Particulars of Steam Generating Units

	Type A	Type B
Maximum capacity, lb per hr	132,000	132,000
Heating surface, sq ft		
Boiler	7,350	5,440
Superheater	3,020	3,220
Air heater	14,000	15,100
Economizer	25,300	21,600
Furnace volume, cu ft	1,100	2,030
Combustion rate at 132,000 lb per hr, Btu per cu ft	21,400	19,300
Steam pressure, lb gage	228	228
Steam temperature, F	680	680
Feedwater temperature, F		
Ahead of economizer	158	158
After economizer	338	338
Mills per boiler	2	2
Capacity of mills, lb per hr	28,700	28,700
Grate area, sq ft	65.7	64.6

STEAM ENGINEERING ABROAD

As reported in the foreign technical press

Feedwater for Velox Steam Generator with 100 Per Cent Makeup

It has often been asserted that, owing to the high rate of heat liberation in the furnace, the Velox steam generator is susceptible to scale formation unless particular attention is given to the feedwater. In answer to this *The Brown Boveri Review* for April cites the case of one of these units operating in a chemical works with 100 per cent makeup. The raw water is far from favorable and the method of treatment is described.

The unit has a capacity of 40,000 lb per hr at 512 lb pressure, 750 F total steam temperature, and supplies steam to a back-pressure turbine, the condensate being employed in process.

The following tabulation gives the analysis of the raw water, the treated feedwater and the boiler water:

Composition	Raw water (average value)	Raw water (min and max values)	Softened raw water after first stage (average value)	Feed-water (average value)	Boiler water (average value)
p in ccm n/10 HCl	..	....	0.25	0.4	14.4
m in ccm n/10 HCl	1.7	1.4–3.9	1.65	1.75	16.5
Transitory hardness (German degrees)	4.8	3.9–8.1	..	...	...
Permanent hardness (German degrees)	1.5	1.1–7.9	..	...	...
Total hardness (German degrees)	6.3	5.0–16.0	0.7	0.1	0.6
CaO in mg/l	..	37 to 118	..	0.1	0.6
MgO in mg/l	..	10 to 32	..	0	0
Al_2O_3 in mg/l	..	0 to 1	..	0.2	...
Cl in mg/l	21.3	21 to 76	..	15.9	170.0
SO_3 in mg/l	..	13 to 28	..	38.4	391.0
SiO_2 in mg/l	14.0	12 to 21	..	13.2	117.5
P_2O_5 in mg/l	..	....	..	2.9	23.5
Caustic Soda figure	..	....	..	...	550

As the maximum and minimum values of the analysis show, the properties of the raw water vary according to the season; also, the water holds in suspension a very fine clay sludge which cannot be removed by filtering without first being precipitated by aluminum and magnesium hydroxide. The bicarbonates are precipitated by caustic soda and a second treatment with trisodium phosphate is necessary to prevent the formation of silica scale.

The entire raw water treatment requires the following procedure:

River Water

First—Treatment with solution of caustic soda and magnesium at 176 F

Second—Sand filter

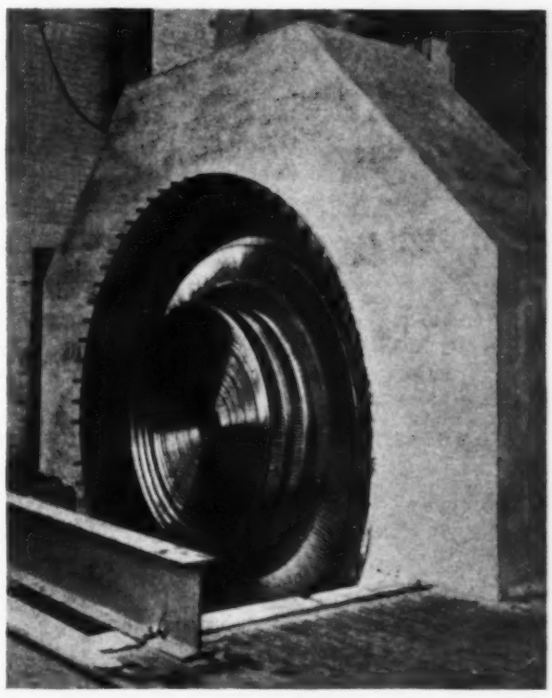
Third—Treatment with trisodium phosphate at 200 F

The amount of blowdown is about 10 per cent, hence the concentration in the boiler builds up tenfold. However, the phosphate ions are also subject to a tenfold increase and, as calcium phosphate precipitates at even smaller concentrations than calcium silicate, the hardness is reduced in the form of calcium phosphate flakes and not as calcium silicate. The former is said to possess the ability to absorb SiO_2 and, therefore, a certain counter-silica scale influence is at work, which is seen from the fact that the silica does not attain the same concentration as the other salts.

Ljungström Turbines at Brighton

Commenting upon the extension to the Brighton Station at Southwick, England, the first unit of which was formally placed in service on May 21, *Engineering and Boiler House Review* of June calls attention to the employment of two 37,500-kw Brush-Ljungström turbine-generators. These are the largest radial flow machines yet constructed for a British power station, although one of 50,000 kw has been in operation for a considerable time at the Vasteras Station in Sweden.

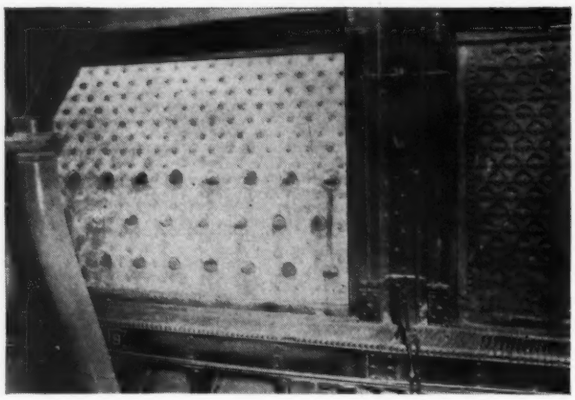
In this type of unit, it will be recalled, the steam during the greater part of its expansion flows in a radial direction



Half of turbine rotor being subjected to overspeed test

through concentric rings of reaction blading secured alternately to the faces of two oppositely rotating disks, each of which is connected through a shaft to its own generator rotor. The speed of the disks relative to one another is double the normal speed of either which in the case of the Brighton machines is 1500 rpm. In each

EAGLE
Super "66"
Stops Heat Waste
on Boiler Headers



Boiler header at left covered with Eagle Super "66." Boiler at right was later insulated with same material. High coverage, with minimum shrinkage, makes this easy-to-apply plastic insulation extremely economical. (Union Electric Light & Power Company, St. Louis.)

Improved Plastic Insulation pays for itself in a few months . . . quick, easy to apply

● It's easy now to stop costly heat loss through boiler headers. These surfaces, with their enormous radiating area, can be quickly covered with Eagle Super "66."

This improved plastic insulation trowels easily on any surface—turbines, boiler drums, flanges and fittings, as well as steam headers.

Engineers who have compared cost sheets find that Eagle Super "66" is remarkably efficient and economical. It gives maximum efficiency up to 1800° —is 100% reclaimable up to 1200°.

Write today for samples and complete specifications.

THE EAGLE-PICHER LEAD COMPANY
CINCINNATI, OHIO

Eagle-Picher offers a complete line of efficient insulating materials for Power Plants. See catalog in Sweet's.

EAGLE EP PICHER

EAGLE
INDUSTRIAL INSULATION

turbine there are 57 rings of radial flow blading and two axial flow single rotation low-pressure stages. The central position of the casing permits a double flow arrangement for these last stages and each disk carries two rows of axial flow blades in addition to radial flow.

The radial flow blades are machined with their roots from the solid bar, and are built up into rings; the nickel-chrome-molybdenum steel strengthening rings which carry the centrifugal load of the blades are secured to the blade roots by rolling the material over the dovetails.

Steam conditions are 650 lb pressure and 850 F. total steam temperature, while a vacuum of 29 in. is specified at the most economical load of 30,000 kw.

Duct Insulation at Hams Hall

Engineering (London) of May 7, 1937, describes the electrostatic dust separator plant for the new pulverized-coal-fired boilers in the recent extension to the Hams Hall Generating Station of the Birmingham Corporation. Of particular interest is the layout of ducts for the flue gases and the insulation employed. With reference to this phase of the installation the article says in effect:

With an electrostatic separator plant it is important that the gas temperature be as high as possible to avoid the risk of falling to the dewpoint and consequent choking and fouling at low loads when the quantity and velocity of the gases are reduced. Therefore, careful attention had to be paid to the insulation of the ducts. This was also rendered necessary by the facts that, owing to a large volume of gas, the employment of mechanical draft was not feasible and that the reinforced concrete chambers of the separator plant were not insulated. Reliance had to be placed on the natural draft provided by the chimney to maintain the velocity. It was decided to use internal rather than external insulation for the reason that it would enable the temperature of the steel plating to be kept as low as possible and thus avoid trouble from expansion and contraction. It was also decided that the risk of corrosion when starting and stopping, at which times the gas temperature is low, would be avoided.

The insulating material employed was a composition consisting of 85 per cent raw magnesia carbonate and 15 per cent pure asbestos fiber. To secure this to the inside of the duct a number of 2 in. by $\frac{1}{2}$ in. cleats and curved flats were fastened to the shell plating by small angle brackets about 3 ft apart around the circumference. Sheets of asbestos cloth were then placed between each cleat to minimize losses by conduction. The magnesia-asbestos composition was formed in blocks 2 in. thick and 6 in. wide cut to suitable lengths. All the joints and voids were filled with plastic material and to protect the insulation and steel work from the acid-laden gas two layers of reinforced concrete were placed over the magnesia-asbestos composition. Before these were placed in position, however, thin sheets of waterproof paper were laid on the composition to prevent its absorbing water from the concrete during installation. A sheet of expanded metal which had been previously dipped in hot bitumen compound was then placed on top of the paper and secured to the curved flats by links of soft iron wire. These allow for expansion and contraction. A layer of $\frac{1}{2}$ in. thick concrete was then applied to the expanded metal and this was followed by a second layer of ex-

panded metal and concrete, bringing the total thickness up to 1 in.

As it was essential for the concrete to be resistant to corrosion and to attack by oxides of sulphur it was composed of granules of broken diatomaceous earth insulating bricks, China clay and ciment fondu mixed in definite proportions. The latter, it is stated, improves the acid resisting properties better than portland cement.

Marine Stokers

A report of the First Annual Conference of the Combustion Appliance Makers' Association of Great Britain which has just been issued comments as follows concerning the status of stokers for marine service:

"Notwithstanding the technical success of stokers operating in a number of services, the progress of mechanical firing at sea cannot be regarded as satisfactory. Ships fitted with mechanical coal firing comprise less than one per cent of the coal-fired ships afloat, and less than one-half per cent of the total world tonnage included in Lloyd's Register. The economic utilization of coal at sea has recently been investigated by the Marine Committee of the C. A. M. A. and a Memorandum was drawn up and submitted to the Secretary for Mines in September 1936. In this Memorandum the opinion is expressed that for many services, and particularly for ships within the range of 1500 to 8000 shp, coal firing can often be more economical than oil. It is further stated that the economics of bunker coal are largely bound up with the efficiency of power generation at sea. Whereas with hand-fired boilers and simple reciprocating engines, a fuel consumption of 1.60 lb of coal per shaft horsepower represents a fair average, ships fitted with high-pressure boilers, mechanical coal stokers and modern turbines or engine-turbine combinations, show coal consumptions from 1 lb down to less than 0.9 lb per shp per hr. The quality of coal taken for these comparisons is in each case of calorific value 12,500 Btu per lb. In the light of the submissions made in the C. A. M. A. Memorandum, a conference of ship owners, coal producers and marine engineers was convened by the Secretary for Mines in February 1937, and a Committee has since been set up to carry the matter further. It is hoped that this may result in an increased use of mechanical firing at sea, and thus bring marine practice into closer correspondence with present-day developments on land."

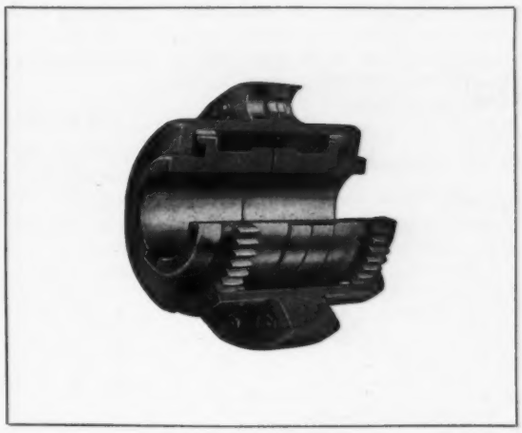
Colloidal Fuel

Progress in the burning of a mixture of pulverized coal and fuel oil for marine use is reported in the June issue of *Industrial Britain*. Experiments extending over a period of five years have been conducted by the Wallsend Slipway & Engineering Company, Ltd., in collaboration with the Cunard Steamship Company and tests have been made on various well-known vessels such as the Berengaria and the Carinthia. The mixture is 60 per cent oil and 40 per cent pulverized coal. It is appreciably cheaper than oil and is believed to hold attractive possibilities for the British coal industry in regaining marine markets for its output.

POOLE

Flexible Couplings

ALL METAL • FORGED STEEL
NO WELDED PARTS



The Poole flexible coupling combines great mechanical strength with an unusual capacity for adapting itself to ordinary shaft misalignments. It has no springs---rubber---pins---bushings---die castings or any flexing materials that require frequent replacement.

Using strong specially treated steel forgings, long wearing gears in constant bath of oil, this coupling eliminates your coupling troubles.

OIL TIGHT • FREE END FLOAT
DUST PROOF • FULLY LUBRICATED

Send for a copy of
***our* Flexible Coupling Handbook**

POOLE FOUNDRY & MACHINE CO.
BALTIMORE, MD.

NEW CATALOGS AND BULLETINS

Any of these publications will be sent on request.

Bearings

A new type of bearing is described and fully illustrated in a catalog of the Fast Bearing Company, Baltimore. In this bearing the load is floated on a pressure oil film with each bearing functioning as a self-contained centrifugal force-feed pump. It is interchangeable with any ball or roller bearing made to international standard dimensions of the same series.

Belt Drives

"Tentacular Drive Data" is the title of a 32-page catalog, No. A-117, issued by Alexander Brothers, Inc., Philadelphia, which, following a history and description of tentacular construction, presents a number of tables and formulas useful in selecting a belt drive. Price lists and weights are included.

Boiler Baffles

The Engineer Company, New York, has just issued a new 16-page catalog dealing with the construction and application of Enco Baffle Walls. The subject is covered under two headings, namely, a description of the materials used and the methods of construction, and the engineering involved in various designs and arrangements. In connection with the latter, numerous photographs and drawings are reproduced showing the application of the baffles to boilers of practically all types and to meet different conditions, especially with reference to various arch designs.

Boiler Feed Pumps

A new line of multistage centrifugal boiler feed pumps, for pressures up to 1200 lb per sq in. is described in a bulletin issued by Worthington Pump and Machinery Corporation. These pumps employ an even number of impellers, facing in opposite directions, to equalize the axial forces and eliminate balancing drums or disks; also, staggered volute construction to effect radial hydraulic balance. They are made in 4-, 6- and 8-in. sizes for a speed range from 2500 to 4000 rpm. Capacities range from 200 to 1500 gpm and pressures up to 1200 lb.

Buromin

The Buromin Company, Pittsburgh, has issued a new bulletin dealing with Buromin as a boiler water conditioning product. The text relates the origin of Buromin and tells how it is used for scale prevention, how it functions to maintain low controlled alkalinity and the part it plays in preventing oxygen corrosion.

Coal Screens

Allis-Chalmers Mfg. Company, Milwaukee, has just issued a revised 12-page bulletin, No. 1476A, devoted to the subject of coal screens, giving illustrations of various types of vibrating screens, representative installation views, as well as sizes and dimensions.

Combustion Instruments

"Portable Combustion Testing Instruments" is the title of a new catalog issued by The Hays Corporation, Michigan City, Ind., covering flue gas analyzers, portable draft gages, flue gas thermometers, combustion test sets and Btu calorimeter. Not only are these instruments described but much helpful information on their use is included, as well as a series of charts for interpreting readings with various kinds of fuels.

CO_2 Meters

Electric CO_2 meters of both the indicating and the recording types are described in a new catalog, No. 3005, issued by The Brown Instrument Company, Philadelphia. A schematic diagram in color illustrates very plainly the operating principle of these meters. Combined CO_2 and flue gas temperature recorders are also covered.

Dry Vacuum Pumps

For handling air and vapors not liquefied in the condenser, and for pulling a vacuum in any closed system in the chemical and process industries, Worthington Pump and Machinery Corporation has brought out an improved line of single-stage and two-stage horizontal dry vacuum pumps for which high volumetric efficiencies are claimed. These are described in Bulletin L-711-B2 which fully illustrates the details, particularly the specially designed feather valves.

Expansion Joint

A new type "S" stainless steel, bellows expansion joint, for pressures up to and including 150 lb per sq in. and temperatures up to 750 F, is described in Bulletin X-37-4 issued by Foster Wheeler Corporation, New York. For higher pressures up to 300 lb a modification of the bellows is employed.

Fans

There is now available for distribution to architects, engineers, contractors and other interested persons, a leaflet published by the National Association of Fan Manufacturers which illustrates and describes standard methods of designating discharge and rotation for centrifugal fans as well as arrangement of drive. The information has been conveniently classified and may be inserted in a standard three ring binder for ready reference.

Furnace Arches

Geo. P. Reintjes Company, Kansas City, Mo., furnace wall and arch manufacturers, announce the development of a simplified arch construction as illustrated in its bulletin No. 201. This construction requires fewer shapes of tile and castings, is flexible in application, has freedom of expansion, and is universally applicable to any existing arch steel work.

Heating Units

A new publication, GED-650, entitled, "Electric Heating Units and Devices" has been issued by the General Electric Company, Schenectady, N. Y. It describes an extensive line of heating units for various industrial applications and appended is much useful information in the form of curves for figuring heat losses, tables for calculating power requirements and data on specific heats of liquids, gases and vapors.

Insulation

A new bulletin dealing with "Stic-tite" has just been issued by Refractory & Insulation Corporation, New York. This is a plastic insulation good for temperatures up to 1800 F and finds extensive use in power plants and for general industrial heat processing equipment, as well as for hot air or gas ducts. The bulletin contains a chart showing comparative values of heat transfer through various insulating materials for given mean temperature differences.

Oil Burning Equipment

"Enco" steam atomizing and mechanical atomizing burner units, as well as combination gas-oil burner units using either steam or mechanical atomizers for capacities up to 100,000 lb of steam per hour are described in Bulletin OB-37 just put out by The Engineer Company, New York. The catalog also covers fuel oil pumping and heating systems for capacities up to 600,000 lb of steam per hour and interchangeable type atomizers for use with pulverized coal and gas burners of various makes.

pH Control

In many power and industrial boiler plants, operators regulating the addition of acid, soda ash, phosphates or other reagents to feedwater or makeup are now guided by a bold dial on which a big black pointer continuously indicates pH. In others, operators simply turn a control setter to the prescribed pH value, and thereafter reagent input is automatically adjusted in response to pH deviation from the control value.

To make this possible a compact electrode assembly automatically detects the pH of a continuously flowing sample of

boiler feedwater or makeup, and a standard Micromax, located wherever convenient, automatically indicates and records pH, or if desired, automatically controls reagent input.

A 20-page illustrated bulletin entitled "To Improve Corrective Water Treatment" has just been issued by Leeds & Northrup Company, Philadelphia, describing features of this equipment.

Proportioning Equipment

A 24-page illustrated catalog has been issued by D. W. Haering & Co. describing the operation and application of proportioning equipment for the feeding of chemical solutions. The use of pitot tubes and fluid pistons is discussed at length.

Pumps

The Gould Pump Company has issued a new bulletin, No. 208, dealing with its line of close-coupled centrifugal pumps. It contains complete information on construction, specifications, ratings and dimensions of 21 sizes of these pumps in capacities from 5 to 1600 gpm and for heads up to 525 ft.

Pyrometers

Pyrometers of the millivoltmeter type are covered in a 40-page catalog issued by The Brown Instrument Company, Philadelphia. These instruments are of the indicating, recording and controlling types. The catalog also describes a new moisture-proof rotary switch, multiple key-type switch, control relays, valve mechanisms, thermocouples and accessories.

Safety and Relief Valves

Crosby Steam Gage and Valve Company, Boston, has just issued an 80-page catalog, No. 101, dealing with its line of safety and relief valves. These are built of steel or alloy steel, according to the pressure and temperature involved, and for a wide range of capacities and steam conditions. Each style of valve is fully described and illustrated in section, and tables giving specifications and prices are included. Appended are tables of American flange standards as approved in 1932.

Spray Nozzles

Bulletin N-615 covering Yarway Involute Spray Nozzles for air conditioning systems and for general industrial purposes has just been published by Yarnall-Waring Company, Philadelphia. It contains useful data on the smaller sizes of Yarway Nozzles built for this service.

Steam Generator

A new catalog just issued by Combustion Engineering Company, Inc., New York, describes its Type VU Steam Generator which is of standard construction, complete in sizes ranging from 15,000 to 250,000 lb of steam per hour and for any steam pressure up to 1000 lb per sq in. This is a two-drum unit, fired with pulverized coal, oil or gas, the burners being located in the front of the furnace with tangential admission of secondary air. The design is symmetrical in that any section taken through the unit from front to rear is similar to any other section so taken and the gases enter the tube bank at a practically constant temperature across the entire width of the unit. The setting is steel encased.

The catalog is fully illustrated with both exterior and cutaway views of the unit, line drawings and detailed sectional views of the burners; also details of the furnace wall construction, mills, etc., as well as descriptive matter and data.

Steam Traps

Publication No. 2663 has just been issued by Cochrane Corporation, Philadelphia, describing and illustrating a steam trap of the straight-line bucket type, which has been added to its line of steam specialties. It is particularly applicable for condensate drainage of steam lines, coils, evaporators, jackets, rolls, mixers, stills, etc., at pressures up to 150 lb. The straight-line installation permits easy disassembling for inspection and cleaning without disturbing piping. There are only two moving parts: bucket and valve. Quick, positive action makes wire drawing impossible. Positive water seal prevents blowing steam. The trap body is of molychrome iron, bucket of drawn copper, valve and seat of hardened stainless steel, discharge tube and guides of bronze. Data, charts and tables explaining how to select proper size trap, as well as prices, are given in the catalog.

Thermometers

The American Schaeffer & Budenberg Division of Consolidated Ashcroft Hancock Company, Bridgeport, Conn. has just issued a new catalog, No. 200, describing its extensive line of thermometers arranged for specific applications. Price lists are included.

Valves

A 16-page illustrated bulletin intended as a guide for selecting valves, boiler mountings, and lubricating devices has been issued by the Lunkenheimer Company. The products are grouped by pressure, type and use, and a convenient thumb-index facilitates its use.

Watthour Meters

General Electric Company, Schenectady, has put out a 16-page bulletin dealing with its two-element, single-disk watthour meters. The instrument is illustrated with various types of mountings, dimensions are given for the several types and schematic connection diagrams are included.

Zeolite Process

A 68-page book entitled, "Zeolite Process for Treating Boiler Feedwater" has just been issued by The Permutit Company, New York. This is more than a catalog; it is, in effect, a treatise dealing with boiler deposits, methods of water conditioning, the hot lime-soda process, the cold lime-soda process, the zeolite process and the equipment involved. A separate chapter deals with zeolite-softened water for railroads and a table is included giving the analyses of typical waters. Another chapter contains much useful information on the conditioning of condensate returns and blowoff control. Appended is a description of the latest "Ranarex" mechanical CO_2 indicator and recorder.

CHRONILLOY ELEMENTS

HOW MUCH IS IT COSTING you to maintain the SOOT CLEANER ELEMENTS in the HIGH TEMPERATURE positions of your boilers? Here is an element sold with an 18 MONTHS SPECIAL UNQUALIFIED SERVICE GUARANTEE. COST MORE? Yes, but WHAT SERVICE LIFE!

BALANCED VALVE-IN-HEAD

FIRST QUALITY IN DESIGN, WORKMANSHIP AND MATERIAL. Back of this IMPROVED SOOT CLEANER HEAD lies years of study to make it trouble free and give dependable service day after day. Analyze before you buy as cheap imitations may be offered.

THE BAYER COMPANY
4067 Park Ave. St. Louis, U. S. A.

Business Notes

THE ERNST WATER COLUMN & GAGE COMPANY, Newark, N. J., announces the appointment of the following representatives: Boig & Hill, 87 Barclay Street, New York, for New York and Connecticut; C. B. McBrearty, 6818 East End Avenue, Chicago, and Engineers Sales & Service of Louisville, Ky. The offices at 342 Madison Avenue, New York, under the direction of W. K. Sowdon are also being retained.

THE HANCOCK VALVE DIVISION OF THE CONSOLIDATED ASHCROFT HANCOCK COMPANY, Bridgeport, Conn., announces the addition of James A. Gibbons to its field sales organization.

THE DAMPNEY COMPANY OF AMERICA, manufacturers of "Apexior," has opened a branch office in the Citizens and Southern National Bank Bldg., Atlanta, Ga., in charge of Ray W. Carter.

THE TERRY STEAM TURBINE COMPANY announces appointment of the following district representatives: Walter Cooke, 846 Baronne St., New Orleans, La.; Cowles & Co., Dallas, Texas; and W. V. C. Jackson, National Bank of Tulsa Bldg., Tulsa, Okla.

CLARAGE FAN COMPANY, Kalamazoo, Mich., has appointed D. B. Chapman as southeastern district manager with offices in the Hurt Building, Atlanta, Ga.

COMBUSTION ENGINEERING COMPANY, INC., has opened a district office at Birmingham, Ala., with J. W. Eshelman as district manager. Associated with Mr. Eshelman will be W. E. Johnson and James T. Potter.

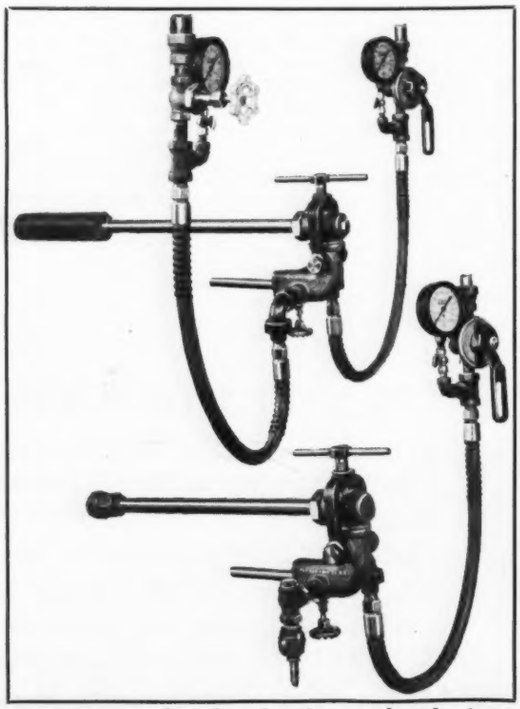
STEEL & TUBES, INC. has appointed Howard H. Loving as its representative in Kansas City.

Performance vs. Grindability

"Pulverizer Performance as Affected by Grindability and Other Factors" was discussed in a paper by Messrs. Frisch and Foster before the recent annual meeting of the A.S.T.M., New York. The conclusions were, that the relative ranking of a coal depends on the method of test used. The two tentative methods, namely, the Ball-Mill Method and the Hardgrove Machine Method, assign quite different relative ratings to the same coal. But these ratings may be correlated in view of the permissible accuracy with which tests may be checked and reproduced by these methods. The authors pointed out that pulverizers of different sizes, though of the same type, do not rank coals alike. Hence laboratory grindability ratings are useful, and may be employed to predict the performance of a pulverizer on a coal of known grindability without test. But this may be done only where the grindability-capacity relationship for the pulverizer has been previously determined by test; also, where the effects of such other factors as feed size, moisture and fineness have been taken into consideration.

At the same meeting, A. W. Gauger of Pennsylvania State College, presented a paper on "The Significance of Ash-Softening Temperature and Ash Composition in the Utilization of Coal" in which he expressed the opinion that the importance of ash fusibility as measured by the A.S.T.M. ash-softening temperature test has been overemphasized. This method is only a qualitative index of the probable seventy of clinker formation and a search must continue for methods which offer promise of being better indices. Several interesting investigations are now under way to this end.

Enco Burners



The illustration shows how, by releasing the yoke clamp, mechanical, air or steam burners and the size of either can be instantly interchanged.

The Enco interchangeable oil burner is made for mechanical, steam or air atomization in capacities up to 100,000 pounds of steam per hour. When applied to a pulverized coal burner, a very flexible dual fuel unit is obtained.

The use of the oil burner does not require any alteration in the coal burning equipment and the change of fuels can be made instantly.

Oil firing is especially desirable for heating the furnace and lighting off the coal when bringing cold boilers on the line.

For banking or low load operation with quick response to a sudden demand for steam.

For assurance of continuous operation against failure of coal equipment or coal shortage.

To reduce fuel cost when oil is available at a favorable price.

We have made many installations of this type and would be glad to cooperate with those looking for better operation and assurance against loss of steam output.

Write for Bulletin OB-37

THE ENGINEER COMPANY
17 Battery Place New York

EQUIPMENT SALES

Boiler, Stoker, Pulverized Fuel

as reported by equipment manufacturers of the Department of Commerce, Bureau of the Census

Boiler Sales

	1937 Water Tube		1936 Water Tube		1937 Fire Tube		1936 Fire Tube	
	No.	Sq Ft	No.	Sq Ft	No.	Sq Ft	No.	Sq Ft
Jan.....	53	261,368	57	287,855	64	83,389	23	24,954
Feb.....	53	206,957	76	408,635	71	87,083	47	50,094
Mar.....	142	758,733	77	325,479	149	210,233	53	47,411
Apr.....	63	333,169	66	339,413	73	67,937	74	97,401
May.....	113	589,347	63	328,872	82	129,782	69	92,403
Jan. to May, Inclusive.	424	2,149,574	339	1,690,254	439	578,424	266	312,263

Mechanical Stoker* Sales

	1937 Water Tube		1936 Water Tube		1937 Fire Tube		1936 Fire Tube	
	No.	Hp	No.	Hp	No.	Hp	No.	Hp
Jan.....	63	25,278	24	10,657	141	21,786	139	16,840
Feb.....	45	16,591	30	11,693	120	20,650	98	13,567
Mar.....	80	38,074	28	10,250	179	24,709	105	14,605
Apr.....	72	37,185	56	30,686	154	23,064	99	12,844
May.....	65	26,327	36	16,742	137	21,443	150	21,326
Jan. to May, Inclusive.....	325	143,455	174	80,028	731	111,652	591	79,182

* Capacity over 300 lb of coal per hour.

Pulverizer Sales

	1937 Water Tube			1936 Water Tube			1937 Fire Tube			1936 Fire Tube		
	No.		Cap. Lb	No.		Cap. Lb	No.		Cap. Lb	No.		Cap. Lb
	N.†	E.†	Coal/Hr	N.†	E.†	Coal/Hr	N.†	E.†	Coal/Hr	N.†	E.†	Coal/Hr
Jan....	35	7	554,900	16	4	235,500	—	2	1,700	—	1	1,000
Feb	2	6	68,300	9	8	165,100	—	4	3,600	—	7	7,700
Mar...	59	3	677,440	10	6	135,300	1	1	2,000	—	1	800
Apr	24	1	257,100	35	3	639,050	—	2	1,100	—	1	1,200
May...	22	—	276,800	22	1	188,900	—	—	—	—	1	1,000
Jan. to May, Inclusive .	142°	17	1,862,540°‡	92	22	1,363,850	1	9	8,400	—	11	11,700

† N—New boilers E—Existing boilers.
° Not including 5 new boilers for storage system.
° Not including 167,000 lb coal/hr for storage system.
‡ Revised as a result of correspondence correcting data for February and March.

Coal Classifications to be Issued by National Coal Commission

The National Bituminous Coal Commission has directed all District Boards to propose standards of classification for coal as to kinds, qualities and sizes, produced in the respective districts, also standard methods and rules for making and applying such classifications. These are to be filed with the National Commission which, after an open hearing, will review and make such modifications as seem necessary before putting them into effect.

DE LAVAL-IMO PUMPS

for Fuel, Lubricating and Heavy Crude Oils

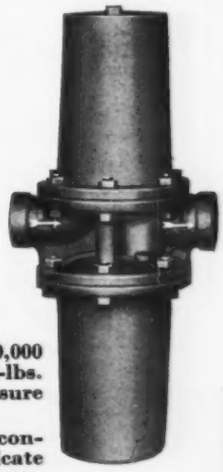
Of the rotary displacement type and having no timing gears or separate bearings. There is but one stuffing box, which is subject to suction pressure only. The flow is continuous and without pulsation and the efficiency is high. Drive can be by electric motor or steam turbine.

De Laval-IMO pumps are built in all capacities and pressures. Described in Catalog L-21.

DE LAVAL STEAM TURBINE COMPANY
Trenton, New Jersey

Compound Steam Traps for

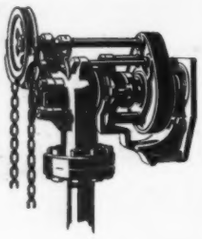
Super-Capacity



- **Standard sizes for loads up to 240,000 lbs. per hr. continuous flow at 600-lbs. maximum pressure. Higher pressure or larger capacity built on order.**
- **Simple, compact, fool-proof construction. No springs, floats, or delicate mechanism. Only three moving parts.**
- **All the advantages of genuine Armstrong Inverted Bucket Design: Quick opening and closing . . . no wire-drawing . . . non-air-binding . . . self-scrubbing.**
- **Ideal for draining large steam purifiers, separators, flash tanks, continuous blow-down systems, de-superheaters, evaporators, etc.**

Write for specification sheets.

ARMSTRONG MACHINE WORKS
814 Maple Street Three Rivers, Mich.



VULCAN SOOT BLOWERS

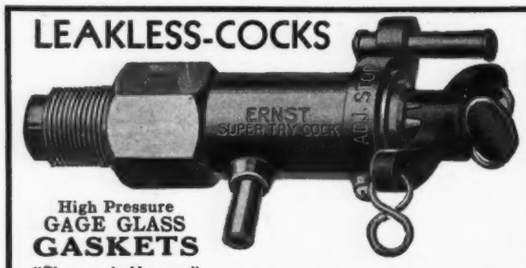
. . . are readily meeting high temperature conditions without makeshift in design, material or parts. The sound and proven principles of the Vulcan valve operating head, bearings and elements guarantee operating economies which make both the annoyance and cost of frequent servicing unnecessary.

VULCAN
SOOT BLOWER CORPORATION
DUBOIS, PENNSYLVANIA

ADVERTISERS

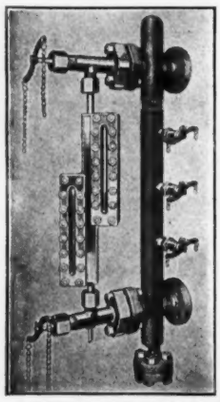
Air Preheater Corporation, The Under Management of The Superheater Company..... 4
American Blower Corporation..... 11
Armstrong Machine Works..... 39
Bayer Company, The..... 37
Buromin Company, The..... 10
Clarage Fan Company..... 5
Cochrane Corporation.....Fourth Cover
Combustion Engineering Company, Inc.....Second Cover, 8 and 9
Combustion Publishing Company, Inc., Book Department..... 12
De Laval Steam Turbine Company..... 39
Eagle-Picher Lead Company, The..... 34
Edward Valve & Mfg. Company, Inc., The..... 13
Engineer Company, The..... 38
Ernst Water Column & Gage Company..... 40
Hagan Corporation..... 10
Hall Laboratories, Inc..... 10
Ingersoll-Rand Company.....Third Cover
Johns-Manville..... 7
National Aluminate Corporation..... 14
Northern Equipment Company..... 2
Poole Foundry & Machine Company..... 35
Prat-Daniel Corporation..... 3
Reliance Gauge Column Company, The..... 32
B. F. Sturtevant Company..... 6
Vulcan Soot Blower Corporation..... 40
Yarnall-Waring Company..... 40

LEAKLESS-COCKS



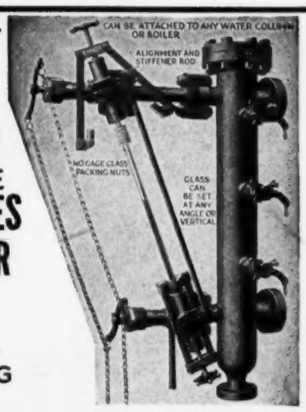
High Pressure GAGE GLASS **GASKETS**
"They won't blow out"

—*SPECIFY*— ●
ERNST HIGH PRESSURE FLAT WATER GAGES

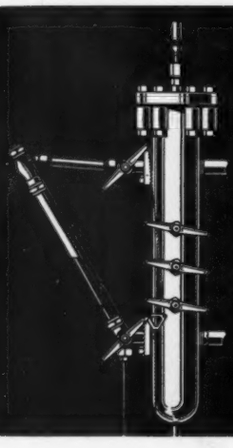


● *SPECIFY*
ERNST SPLIT-GLAND ADJUSTABLE WATER GAGES VERTICAL OR INCLINED

CATALOG C


CAN BE ATTACHED TO ANY WATER COLUMN OR BOILER
ALIGNMENT AND STIFFENER ROD
NO GAGE GLASS PACKING NUTS
GLASS CAN BE SET AT ANY ANGLE OR VERTICAL

ERNST WATER COLUMN & GAGE CO. NEWARK, N. J.



POSITIVE, POWERFUL, HAIRTRIGGER ACTION

The Floatless HI-LO Alarm Water Column using *Balanced Solid Weights.*

Send for celluloid working model and Catalog WC1803.

YARWAY

YARNALL-WARING CO. PHILADELPHIA, PA.